Jyotiska

SOUVENIR

V ALL INDIA AMATEUR ASTRONOMERS' MEET

PATHANI SAMANTA PLANETARIUM

BHUBANESWAR

JYOTISKA

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V ALL INDIA AMATEUR ASTRONOMERS MEET
14-16 JANUARY 1995
BHUBANESWAR

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Bhubaneswar-751013

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सत्यमेव जयते
CHIEF MINISTER
ORISSA STATE

BIJU PATNAIK

BHUBANESWAR
Date : 10.1.95

MESSAGE

I am happy to learn that the 5th All India Amateur Astronomers' Meet is being held at Pathani Samanta Planetarium, Bhubaneswar from 14th to 16th January, 1995 and that a souvenir entitled "JYOTISKA" is being broughtout on the occasion.

Man has always looked at the limitless expanse of space with awe and wonder. Whether it is a child gazing at the moon with innocent curiosity, or an astronomer trying to unravel the mystery of stars with his scientific instruments, all of them have been bound by a common spirit of adventure and discovery.

I commend the effort to make astronomy an interesting pastime for the non-professionals and congratulate those who are making the Amateur Astronomers' Meet possible.

Sd/-
BIJU PATNAIK

MESSAGE

I send the Meet my best wishes and hope that with the enthusiastic backing from Orissa the amateur astronomy movement will flourish. I am very happy to note that your Planetarium is supporting this meeting.

(J. Narlikar)
Director
I.U.C.A.A., Pune

MESSAGE

It gives me great pleasure to extend my hearly felicitations to the organizers of the V All India Amateur Astronomers' Meet, 1995 being held from the 14-16 January, 1995. The future of science and, in particular, Astronomy will depend on the extent to which the younger generation is given the impetus and inspiration for creative studies and research. By organising this All India Amateur Astronomers' Meet, the Pathani Samanta mPlanetarium has set the pace in nthis direction.

Samanta Chandrasekhar was one of the most original minds of our country and could achieve unbelievably accurate results based on indigenous astronomical calculations. This has stupefied the great astronomers of the west and remains a perennial source of inspiration for all of us who profess science. I have no doubt that the discussions which will take place during 14-16 January, 1995 will go a long way to bring about a material advancement in the field of Astronomy. It is my hope that a deeper understanding of our Astronomical traditions will help us also to comprehend the scientific basis of our Astrological heritage which has been generally ignored or misunderstood.

My best wishes for very successful proceedings of the V All India Amateur Astronomers' Meet.

(T. Pati)
President
Orissa Bigyan Academy

PREFACE

It is a happy occasion that the V All India Amateur Astronomers' Meet is being held at Bhubaneswar during 14-16 January, 1995. The Meet is being organised by Pathani Samanta Planetarium under the auspices of the Science & Technology Department, Government of Orissa, in collaboration with Samanta Chandra Sekhar Amateur Astronomers' Association (SCAAA), the Regional Science Centre, Bhubaneswar and Srujanika. The Meet is being supported by Inter-University Centre for Astronomy and Astrophysics (IUCAA), C.I.A.A., Orissa Bigyan Academy, Institute of Physics, BHubaneswar, Utkal University, Forest & Environment Department, Government of Orissa, I.D.C., Orissa, and many other state and national level organisations.

It is for the first time that such a Meet is going to be held in this temple city of Orissa. In fact, Bhubaneswar, in the eastern coast of India has been one of the great cultural centres through ages. Besides, Orissa has a rich tradition in astronomy, being the birth place of Satananda (1060-1110 A.D.) and Chandra Sekhar Singh Samanta (1835-1904 A.D.). Therefore, this Meet will rejuvinate the spirit and temper of the amateurs all over the country and will instili new vigour in the creative youth of the state.

The V All India Amateur Astronomers' Meet will be of specific significance for two things, namely, it will provide a platform for the amateur and professional participants to share the experience gained during the last comet crash on Jupiter and provide a nice occasion for planning co-ordinated programmes for the Total Solar Eclipse - 1995 to be observable in India. Besides, papers will be presented on the life and work of Samanta Chandra Sekhar, one of our unsung great men of science, who is hardly known beyond the boundary of Orissa state.

It adds, further to our pleasure that we are able to bring out a souvenir for this year's Meet, the second in a row, with the name 'JYOTISKA'. We are overwhelmed by the prompt response of the professional scientists and amateur workers all over the country, in contributing articles for this publication. We have tried to accommodate contributions having relevance and value.

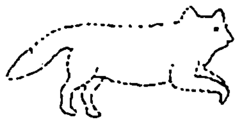
But we are grateful to all who gave us their mind and time through their articles, which we have presented in this souvenir and those which we could not accommodate. Thanks are due to the collaborating institutions and their members for spontaneous help and co-operation. Special thanks are due to Sri G. B. Pradhan and Sri S. Pattnaik, who have painstakingly entered, edited, laid out and set the final shape for printing. We are thankful to Sri B. K. Jena for cover design and the figures.

Members, Souvenir Committee

CHIK-MIK STARS

B. K. Pattnayak
(Original Oriya)

'Chik-Mik, Chik-Mik' glittering stars
'Jhil-mil, jhil-mil' dazzling stars
Yellow, blue, red shining stars
Large and small, a lot of stars
Stars and stars, stars and stars
The starry sky all strange, afar.



As the sun sets
And night lowers
Darkness fills all space
Now the little twinkling stars
Show their funny face
Chik-mik, Chik-mik glittering stars'

Join the stars to stars in steps
See the sky now full of shapes
It has opened an unending book
With birds and animals, go and look,
Stars and stars, stars and stars
'Chik-mik, chik-mik' glittering stars.

Translation : P. C. Naik

CONTENTS

GENERAL

SAMANTA CHANDRA SEKHAR - THE INDIAN TYCHO

Prahallad Chandra Naik

Here are a few legends without specific dates that the first biographer of Samanta Chandrasekhar, Pandit Sri Chandra Sekhar Mishra mentions in his work of 1932. The legends are also supported by an independent lyrical ellegy composed by the second son of Samanta on his "Mahaprayana" in 1904.

That Sri Samanta was attending the wedding of one of his relatives in the island state of Parikud in the Chilka lake, where he was introduced to the king of Manjusha. He was then invited to Manjusha and asked to estimate the height of the Mahendra mountain. Samanta's estimate exactly agreed with the earlier measurements and the king of Manjusha informed the matter to the then English Government of Madras.

Later on, Sri Samanta calculated the occurrence of a solar eclipse to be visible from England and communicated this information to Manjusha, which was subsequently transmitted to the Madras Government. There was an astronomer, Sri Raghunath Acharya in Madras, (Must be Chintamani Ragoonathachary), who contradicted Samanta's prediction. But Samanta's calculations came true. Further, Samanta calculated the transit of Venus over the Sun and to Sri Raghunath Acharya together with calculation. It must have been the last transit of Venus visible from India on December 8, 1874. And the eclipse occurred in time. In another instance, Samanta Chandra Sekhar predicted a solar eclipse with timing to be visible in America, which Sri Jogesh Chandra Ray informed to the West.. Of course, the prediction came true with the variation of a few seconds.

These and many more are the legends and lores which are mostly true, that surround the life of the great astronomer' Mahamahopadhyaya Chandra Sekhar Singh Harichandan Mahapatra Samanta, who happens to be the last link of the long order of great Hindu astronomers like Aryabhata, Varahamihira, Brahmagupta and Bhaskaracharya. The contributions of our illustrious ancestors are contained in their immortal classics, Surya Siddhanta, Aryabhatiya Panchasiddhantika, Brahmagupta Siddhanta and Siddhanta Siromani. So also is the Siddhanta Darpana of Samanta Chandra Sekhar, a classic treatise in traditional astronomy, which is a systematic record of his life long relentless research work composed in beautiful metrical sanskrit verse. He is popularly known as Samanta Chandra Sekhar and more so as Pathani Sananta, in Orissa.

Chandra Sekhar was born in royal family of one of the princely states of pre-independence Orissa, in Khandapara in 1835. His primary education was initiated by a Brahmin teacher and thereafter he started teaching himself Lilavati, Bijaganita, Jyotish, Siddhanta, Byakarana and Kabya out of the family library. Of course, it is mentioned by the biographers that his father introduced him to the identification of some stars.

Chandra Sekhar started doing astronomy at the age of fifteen. The blue sky with its stars and planets was his observatory. The Siddhantas dealing with the instruments give hardly a hint here and there, which were to be improvised all by himself. He noticed that the Siddhantas were not correct in the sense that, the planets did not appear

in the sky as per the ephemerides calculated after them. So he took on the task to himself and started his observations day and night checking every figure appearing in the Siddhantas unaided, but undaunted. He started recording his observations and formulations in the form of a treatise at the age of 23 and completed it in 11 years at the age of 34 in 1869. But it took thirty years for the work originally written on palm leaves to appear in Devanagari - on paper in 1899.

Of course, all those thirty years, the scientist was observing and checking all that he had written. But his work came to lime light through his acquaintance with Sri Mahesh Chandra Nyaya Ratna, the Principal of Sanskrit College of Calcutta, who came to know about Samanta from the observance of rituals of the Jagannath Temple at Puri according to Samanta's almanac adopted since 1876. Later on, Samanta's work and genius were introduced to Sri Jogesh Chandra Ray, the then Professor of Ravenshaw College, Cuttack. Sri Nyaya Ratna and Prof. Ray were instrumental in bringing Chandrasekhar's work to world recognition. Chandrasekhar was awarded the title of Mahamahopadhyaya by the British Govemment in 1893 and "Siddhanta Darpana" was published from a Calcutta Press with the financial support of the king of Athmallick and partially by king of Mayurbhanj under supervision of Prof. Ray.

The Oriya translation of apparently inaccessible classic, "Siddhanta Darpana" has been published in 1975 and 1976. The contents of Darpana looks amazing and unimaginable as the achievement of a single mind. Chandra Sekhar has observed, verified and corrected all that was known to the Hindu astronomers for thousands of years. Very often he has gone beyond them to discover new phenomena and formulations and came out with predictions claimed to remain valid for at least ten thousand years to come. He has given original contributions to four important aspects of astronomy, namely, (i) Observation, (ii) Calculation, (iii) Method of measurement and instrumentation and (iv) Theory and model.

Of the innummerable originalities of Siddhanta Darpana through its 24 chapters and 2500 slokas, we slightly touch here only most famous three discoveries, namely,

a) Three anomalies of Moon

b) The Mana Yantra

c) Peculiar heliocentric model

In his observation of Moon, Chandra Sekhar detected some important perturbations unknown (as described by Prof.J.C. Ray) to any of the earlier Hindu school of astronomers. These perturbations were,

i) Tungantara (|Evection)

ii) Pakshika (Variation) and

iii) Digamsa (Annual equation).

In Samanta's observations, the maxima of these irregularities are 2" 40'. 38'12" and 12' respectively . Of course, modem astronomy gives quantitative expression for these irregularities in the framework of gravitational celestial mechanaries. But Samanta's calculations, unaware of these developments, as elucidated by J. C. Ray, are really remarkable.

An instrument that makes Pathani Samanta a myth in Orissa is his Mana Yantra. He is known to have measured the positions of stars, stellar separations and heights of mountains with this multipurpose instrument. There is a detailed description of the Yantra in the Darpana. But here we present a simplified version of the same instrument as described in the same text elsewhere. The instrument is essentially a tangent staff in the form of a "T" as depicted in the figure (fig.1) with holes notched at measured intervals on the vertical arm. Careful use of the device can give both height and distance of the mountains and other distant nobjects. It may be worthwhile to mention that Samanta Chandra Sekhar devised and used handy instruments with wood and bamboo sticks and using them could make accurate observations in contrast to the mamoth yantras built by Sawai Jaisingh some one and half century earlier.

In respect of theory, Samanta Chandra Sekhar stands apart from all other Hindu astronomers. Excepting Aryabhata of the 5th Century who advocated in support of a rotating earth, almost all Hindu astronomers subscribed the geocentric hypothesis. But Samanta Chandra Sekhar comes out with a quite different model described in Siddhanta Darpana, a conclusion based solely on his own observations. This model, of course, is geocentric with the exception that the five planets Mercury, Venus, Mars, Jupiter and Saturn revolve round the Sun and the Sun with this retinue in turn revolves round the Earth (fig.3). Strikingly enough, this model coincides with exactly a similar concept advocated by Tycho Brahe of Europe in the 16th Century .

Prof. J. C. Ray has drawn a number of parallelisms between Chandra Sekhar and Tycho in his English introduction to Siddhanta Darpana. But Nature (March 9, 1899) comments, "Prof. Ray compares the author very properly to Tycho. But we should imagine him to be greater." The journal "Knowledge (January-December 1899) outlines the relevance of Siddhanta Darpana in the modem context ; "But the work is of importance and interest to us, Westerns also. It demonstrates the degree of accuracy which was possible in astronomical observation before the invention of the telescope and it enables us to watch as it was, one of the astronomers of hoary forgotten antiquity actually at work before us - today".

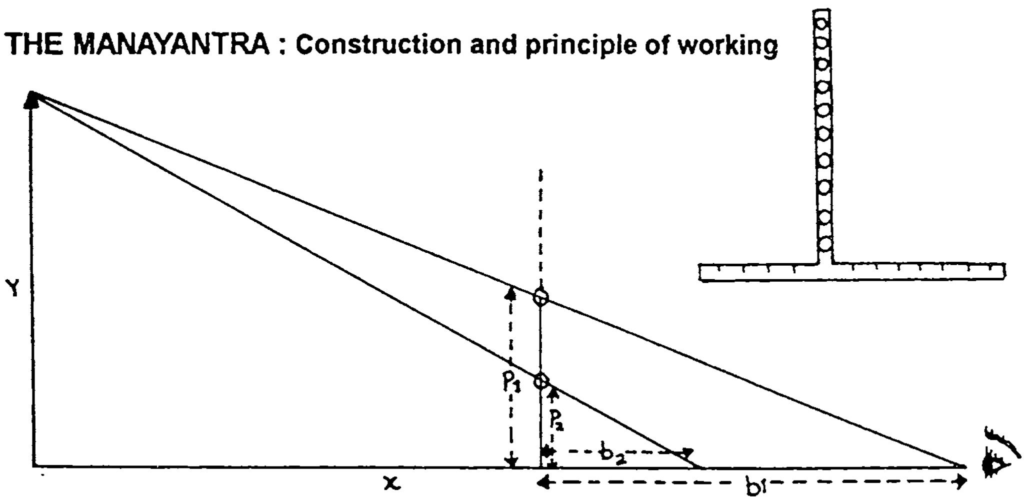
Samanta Chandra Sekhar lived and worked when the English ruled over the country with utmost might. It is believed that he came to know of the development of westem astronomy through Prof. J. C. Ray. He must have been enlightened on various arguments in favour of the well-accepted heliocentric theory. But Pathani Samanta was unmoved. With unflinching faith on his naked eye observations, he went on advocating in favour of the geocentric hypothesis and even did not hesitate to retain a stanza in Siddhanta Darpana which is a direct challenge to the Westem astronomers. The strong intellectual courage of the author can be gauged from his fearless declaration in the following concluding sloka of the Siddhanta Darpana.

ब्रह्माण्डाखण्डभाण्डस्थिरतरधरणीमण्डळभ्रान्तिशौण्ड
प्रोद्दण्डैलण्डदन्ताबळबळदळनाकुण्ठकण्ठीरबश्रीः ।
सोयं नीळाद्रिसिंहान्बयबदनदरीनिर्गतः प्राप्तदुर्गः
स्फीत स्बख्यातिरस्तु प्रथमबिगणितस्कन्धसारः प्रबन्धः ।

Here comes my treatise, out right from the cave of Niladri Singh clan as a mighty lion to quell the English astronomers who pose themselves as a herd of mammoth elephants contradicting the view that the Earth is static in the midst of a moving universe.

It is unfortunate that we in India are ignorant of this genius and his work for about a century. Only recently he has found a brief mention in "Astronomy in India" published by the IUCAA. But again, Samanta and his Siddhanta Darpana have not found their place in the table of Siddhantas given by Prof. Kochhar and Narlikar. Siddhanta Darpana is not a work of historical curiousity only. It has immense relevance and use. Right from 1876 it has been the standard source guiding the preparation of Oriya almanacs which regulate the day to day life of the people of the state. To be more specific, Siddhanta Darpana prescribes the timings for observance of various regular rituals in the Temple of Lord Jagannath of Puri; the temple being regarded as one of the four great centres of our cultural unit. Besides, celestial events like eclipses, occulations, conjunctions and transits; all occur as per the prediction of the Darpana. So, the work has great value of practical use in the positional astronomy today and also, as claimed by its author to remain valid for at least 10 thousand years to come. Infact, Samanta Chandra Sekhar, the Indian Tycho is one of our "Unsung Greatmen of Science".

THE MANAYANTRA : Construction and principle of working



The mountain of height y located at a distance x from the point of observations is looked through an appropriate hole of the vertical arm to coincide with one end of the horizental arm. The same procedure is repeated through another hole which ncoinciding the other end with the npeak. As is clear from the diagram, from similar triangle.

$$\frac{y}{p_1} = \frac{x + b_1}{b_1}$$

and

$$\frac{y}{p_2} = \frac{x + b_2}{b_2}$$

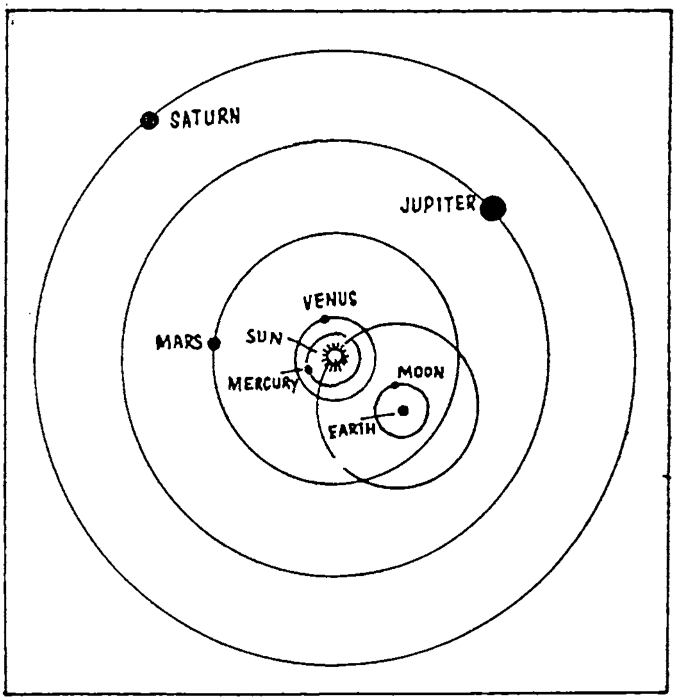
These two equations may be solved to give,

$$x = \frac{p_1 p_2 (b_1 - b_2)}{p_2 b_1 - p_1 b_2}$$

$$y = \frac{b_1 b_2 (p_2 - p_1)}{(p_1 b_2 - p_2 b_1)}$$

This is a simplified version of the multipurpose instrument devised by **Pathani Samanta.**

Tycho and Pathani Samanta Model



Deputy Director
Pathani Samanta Planetarium
Bhubaneswar

INSTRUMENTS OF PATHANI SAMANTA

N. B. Sahu

It has always been a great pleasure to write something on Pathani Samanta, the man who devoted his entire life in exploring mysteries of the sky inspite of personal hardships and agonies. Grown up within the hills and jungles of his little village in an orthodox society of the British era, he never had the opportunity of receiving any formal systematic education nor coming in contact with any modern instrument or astronomer. It is only through the traditional family practice of astronomy that he was initiated into the field which he extended and enriched aided by his practical observation.

He is more known as an indigenous instrument maker and for his practical observations of the night sky. In the context of the highly sophisticated instruments in use these days for astronomical measurements capable of even one-millionth part of accuracy, it will be interesting to know the type of instruments he was actually using.

His instruments can be broadly classified into three categories, i.e. instruments for measuring time, versatile instruments and armillary sphere. The instruments were mostly made up of wood, bamboo pieces and hardly of metallic parts.

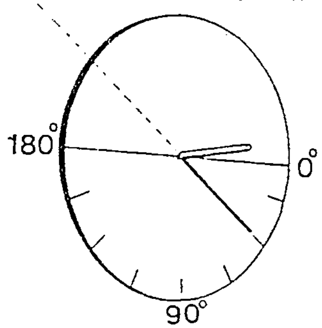
Instruments for measuring time includes sun-dials like Chakra Yantra, Chapa Yantra, Golardha Yantra and of course, a water clock called Swayambaha Yantra. Chakra Yantra, which measures time for an entire day, consists of a calibrated wheel with an axis at the centre. Chapa Yantra, basically a calibrated semi-circle with an axis pointed towards the pole star, measures time for half of a day. Golardha Yantra is a hemispherical sun-dial.

The instruments which were for versatile use mainly include, what is called a Shanku and Mana Yantra. Sanku, or gnomon as it is popularly known, consists of a stick of measured height fixed vertically on a levelled ground. By measuring the shadow length of this stick cast by the Sun, it was possible to determine the local time, the altitude, zenith distance and declination of the Sun, its position in the zodiac, latitude and directions of a place and many other things. But the instrument most favourite to him, the Mana Yantra consists of a staff to which attached a cross-piece in the form of a "T" . It readily measures angles in the sky as well as on the ground. Both Shanku and Mana Yantra can also be used to determine the beight and distance of a hill, tree or cloud. Of course, for such task, two separate measurements from two different distances have to be taken.

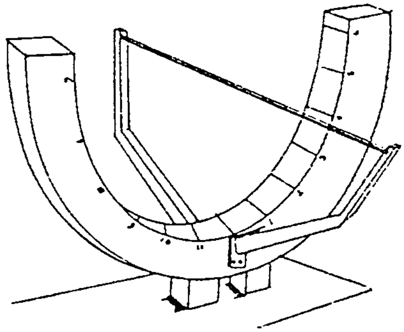
Armillary Sphere, or Gola Yantra, was a very common device popular among classical Hindu astronomers. It was used as a demonstration kit for showing to the students various great circles used in astronomy as well as for determining the position and motion of planets. Pathani Samanta devised an innovative version of armillary sphere capable of measuring the longitude and declination of planets, and hence, it could talk of their direct and retrograde motion in the sky.

His unquenched thirst for astronomy and characteristic lifestyle remind us a verse of Immanuel Kant, the German Philosopher, which says :

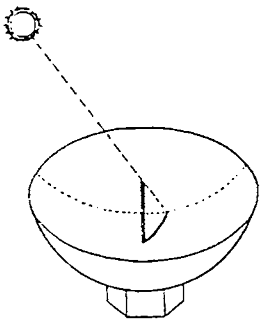
Two things fill the mind with
Ever increasing wonder and awe,
The starry heavens above me
And the moral law within me.



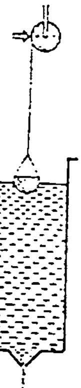
Chakra Yantra : measures the instantaneous zenith distance of the Sun from which time is calculated.



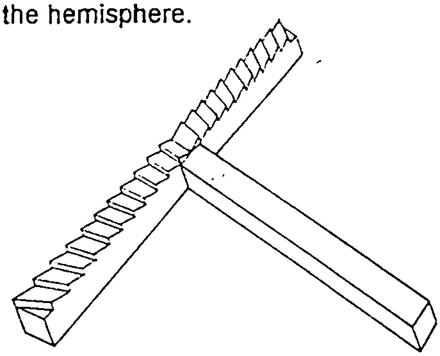
Chapa Yantra : The time is indicated by the shadow of the axis on the calibrated semi-circle.



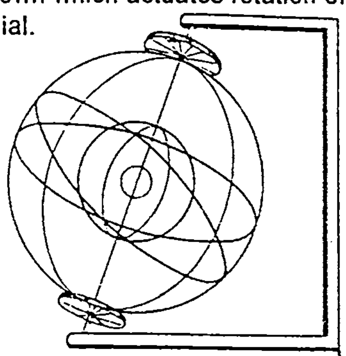
Golardha Yantra : The shadow tip of the axis moves over a circle during a day drawn on the hemisphere.



Swayambaha Yantra : The falling drops of water in a tube makes a hemisphere to go down which actuates rotation of a time dial.



Mana Yantra : The cross-piece is cut into stairs at 4° angle each and each stair is further sub-divided at half a degree angle.



Gola Yantra : a highly simplified version of the actual instrument.

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PATHANI SAMANTA AND MOTION OF EARTH AROUND THE SUN

T. Pradhan

People of Orissa speak with great pride how Pathani Samanta challenged the British view that the Earth goes round the Sun. I never understood how an astronomers of the calibre of Pathani Samanta could do this until I came across an Oriya translation of the relevant slokas in Sidhanta Darpana, the treatise written by him. It is clearly stated there that in a two-body system such as the Sun and the Earth, both revolve around their common "bharakendra" rather than the Earth revolving around the Sun. The Samanta explains this as follows:

Hang two massive objects, one heavier than the other from two ends of a rod. Balance the rod by a string tied to it and moving it from one end to the other like one does in a country weighing device. In general the rod will not be horizontal. But at a certain point the rod will become horizontal. This point on the rod is the "bharakendra" of the two objects. The two objects move in circles around this bharakendra, the heavier in a smaller circle and the lighter in a bigger circle; because the bharakendra is nearer the heavier object. In a similar way the Sun and the Earth move in orbits around this common bharakendra. Because the mass of the Sun is very heavy compared to that of the Earth, the bharakendra lies deep inside the Sun very close to its centre. It is on account of this, that the British say, the Earth moves around the Sun'. But this is an approximate description. In the case of the Sun-Jupiter system, the bharakendra is well outside the sun. One can not therefore say, that Jupiter moves around the Sun.

The description of the Earth - Sun motion with the Sun going around the Earth would be mathematically equivalent to that of the Earth going round the Sun on account of Gablian Principle of relativity if the existence of other heavenly bodies such as distant stars is ignored. Immagine that you are on a train by the side of another train. It will be impossible to tell which train is moving unless you look at a third object such as a distant tree which would appear to move if your train is in motion. A similar thing happens in the Sun-Earth system. If the Earth is moving around the Sun, distant fixed stars would appear to move and complete a closed path during a year. This apparent motion of distant stars which is called "Parallax" is so minute that it can be detected with the aid of precision telescopes. Such parallax was first observed in the nineteenth century which conclusively proved that the Earth moves round the Sun,(strictly speaking around the bharakendra close to the centre of the Sun). Pathani Samanta could not have observed this parallax with his Manayantra. After observing stars through the telescope at Ravenshaw College when Professor Jogesh Chandra Ray took him there, the Samanta is quoted as having said "If only I had this instrument in my younger days"; things would have been entirely different if the Samanta had access to high resolution telescope and other astronomical equipments and facilities available to westem astronomers of his time. It will not be an exaggeration to say that he would have possibly emerged as another Newton.

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SIDDHANTA DARPANA **:** A Treatise on Astronomy. By Mahamahopadhyaya Samanta Sri Chandrasekhara Simha. Edited with an introduction by Jogesh Chandra Ray, M.A., Professor of Physical Science, Cuttack College. (Calcutta, 1897).

Of all the numerous works on astronomy that have been poublished within the last few years, this is by far the most extraordinary and in some respects the most instructive. It is written in Sanskrit by a Hindu of good family of Khandapara in Orissa, and is a complete system of astronomy founded upon naked eye observations only, and these made for the most part with instruments devised and constructed by the writer himself. Those who read the sixty pages of the introduction in English, which the fellow countryman of the author, Prof. Chandra Ray, of Cuttack College, has written, will certainly regret that the barrier of an unknown tongue debars them from a more intimate acquaintance with the very striking personality that Prof. Ray describes. The work to which Chandrasekhara has devoted himself, and which he has carried out with very conspicuous success is this : The native Hindu almanacs computed from the Siddhantas were falling into serious error, and no two current almanacs agreed in their computations. Chandrasekhara, therefore, has re-determined the elements of the old Siddhanta, but has rigorously continued himself to the ancient methods, his principal instrument of observation being a tangent-staff, devised by himself, of a thin rod of wood twenty-four digits long, with a cross-piece at, right angles to it. With these, rude means he has obtained an astronishing degree of accuracy ; his values for the inclinations of the orbits of the nearest planets are correct to the nearest minute in almost every instance. The ephemerides computed from his elements are seldom more than a few minutes of arc in error, whilst the Bengali almanac may be in error as much as four degrees. To Hindus, for whom their religious observances are regulated by astronomical configurations, this work by none of themselves, a strict follower of the severest laws of their religion, and conducted throughout solely by traditional Hindu methods, is of the highest importance, as it removes the confusions which had crept into their system, without in the least drawing upon the sources of western science. But the work is of importance and interest to us westerns also. It demonstrates the degree of accuracy which was possible in astronomical observation before the invention of the telescope, and it enables us to watch, as it were, one of the astronomers of hoary, forgotten antiquity actually at his work before us to-day.

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A MODERN TYCHO

Siddhanta Darpana ; a Treatise on Astronomy. By Mahamahopadhyaya Samanta Sri Chandrasekhar Simha. Edited with an introduction by Joges Chandra Ray, M.A., Professor of Physical Science, Cuttack College, Calcutta, 1897.

Any one who reads the very interesting introduction of sixty one pages that Prof. Ray has attached to this Sanskrit work will regret very much his inability to faith on the work that follows. For therein is contained the results of the patient and industrious inquiry of one who, unaided by the accumulated knowledge of Western astronomers, resolutely set himself to solve the problem of celestial mechanics by the aid of such instruments as he could fashion himself, and where the time honoured clepsydra supplied the place of the sidereal clock. The only assistance he seems to have had were the similar rough observations of Bhaskara (bom 1110) and some still older observers. Prof. Ray compares the author very properly to Tycho. But we should imagine him to be a greater than Tycho, for without the same assistance, without the encouragement of kings and the applause of his fellows, he has advanced his favourite science quite as effectu-

ally as did the Danish astronomer. It is especially curious to notice that the system at which Chandrasekhara ultimately arrived, and the explanation he offers of it, bears a very considerable resemblance to that which Tycho taught. The author has never been able to convince himself that the earth turns on its axis, or that it goes round the sun; but to the planets he assigned heliocentric motion, much as Tycho did.

We get some notion of the success that attended the work, and of how much it is in one man's power to accomplish, if we examine the differences between the values he assigns to some of the constants of astronomy and those in use with ourselves. The error in the sidereal period of the sun is 206 seconds : of the moon, 1 second : Mercury, 79 seconds : Venus, about 2 minutes : Mars, 9 minutes : Jupiter, an hour : and Saturn, rather more than half a day. The accuracy with which he determined the inclination of the planets to the ecliptic is still more remarkable. Mercury offers the largest error, and that is only about two minutes. In the case of the Solar orbit the greatest equation to the centre is only 14 seconds in error. In the Lunar theory, the revolution of the node has been concluded with an error of about 5.5 days, less than the thousandth part of the whole period : while he has independently detected and assigned very approximate value to the evection, the variation, and the annual equation.

The main object that Chandrasekhara had before him seems to have been to correct the calendar, and regulate the daily ritual of the Hindu religion. No two almanacs, Prof. Ray tells us, agree; but any attempt to introduce the Nautical Almanac and its acknowledged accuracy would prove unsuccessful. The necessary corrections and unification must, to be acceptable, come from within and be the work of a Hindu, uninfluenced by foreign education. The work of Chandrasekhara has received the sanction of the honoured Rishis, and the adoption of the corrections which he has shown to be necessary will exert upon native society a beneficial influence, whose importance can be hardly overrated in a community where a correct almanac is an indispensable equipment of every household. We should like much to linger over Prof. Ray's remarks on the subject of precession and his chronological deductions. These and many other points are discussed with great ability, though Prof. Ray modestly disclaims any special astronomical capacity. The effect is to leave us at every page with a higher opinion of the author laboriously recording his observations on a palm-leaf, and unselfishly devoting his life to the services of his countrymen, who do not appreciate the nobility of the effort and the entirety of his devotion. We are in full sympathy with the editor when he writes thus of the author, of his privations and his star-gazing.

"What has he done after all ? asks the impatient critic. To him I would say - Is it not enough to find in this man a true lover of science, who, ,regardless of other people's unfavourable opinion of his work, their taunts and dissuasions, has devoted his whole life to the one pursuit of knowledge : who has shown the way to original research amidst difficulties serious enough to dishearten men in better circumstances : who has employed his time usefully, instead of frittering it away like the usual run of men of his rank on a work which guides the daily routine of millions of his countrymen. W.R.P.

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KNOW THE NAKSHTRAS

P. K. Mishra

In its general connotation the word naksatra means a star. However, in Indian astronomical literature it means two things, viz.

(a) Sections of the ecliptic measuring 13.20' each starting from Sayana Mesadya. This point coincided with the vernal equinox in 285 AD.

(b) Asterisms lying along the apparent path of the moon among the fixed stars. Most of them form parts of the 12 zodiacal constellations while others belong to nearby constellations. They are also called lunar mansions (manzil in Arabic).

Each asterism has been assigned a yogatara or reference star whose position with respect to the asterism has been specified in the suryasidhanta. Most of the sidhantas give the co-ordinates of the yogataras in a equatori ecliptic co-ordinate system which remains invariant with respect to the precession of equinoxes. The yogataras can be easily located with the descriptions and co-ordinates so as to form reference points for measuring the positions of the moon and the planets.

Jones(1) and Colebrook(2) critically compared the constellations given in the Greek, Arabic and Indian systems of astronomy and came to the conclusion that the Indian naksatra system developed independent of the others. Colebrook has even suggested the hypothesis that the Arab manzils of the moon had been borrowed from the Indian system of naksatras.

Mention of the naksatras occurs in the vedic literature and in the Puranas. The vedanga Jyotisa names them in a symbolic form. The time of this work is said to be between 600 - 400 BC. In later astronomical literature, we come across them in the writings of Varahamihira. In his Vrhatsamhita he describes the number of stars in each naksatra. In a later work by Srinivasa named Dipika, the shapes of the naksatras have been described. The most widely accepted description of the naksatras is due to Sripati (11th century AD). His book Ratnamala contains the assumed shapes of the naksatras and the number of stars in each in four slokas which have been quoted by Munis-

vara in his sidhantasarvabhauma (17th cent. AD) and also by Jones[1]. Other works such as Sakalyasamhita, Muhurtacintamani and Ratrilagnanirupanam by Kalidasa enumerate the shapes and number of stars in the naksatras with little variation from Sripati. Colebrook [2] has accepted Sripati's work as standard and has mentioned the data from other sources. More recently Samanta Chandrasekhar in his magnum opus, Sidhanta Darpana, has summarised the available data but has followed Sripati. Table I lists the data from Sripati, Varahamihira and Samanta Chandrasekhar. Study of Table I reveals that the data from the three sources are, by and large, the same through in some cases there are significant differences. These are in the number of stars in case of Uttarasadha and Uttarabhadrapada. In uttarasadha, Varaha has evidently included some fainter stars and in Uttarabhadrapada, he seems to have included some of the brighter stars of the constellation of Andromeda to make up an excellent likeness of couch.

Table II shows the identification of the stars in each naksatra in terms of modern astronomical nomenclature. The first column is due to Burgess from his translation of the Suryasidhanta (1860) and the second is due to Saha and Lahiri taken from the report of the calendar reform committee (1955) Abhayankar[5],[6] has followed the latter except in two cases viz Punarvasu and Ardra.

Comparison of the data in the two tables brings forth a number of discrepancies in the Table II. These are discussed below.

(a) In Table II Asvini has been assigned only two stars while all the authorities quoted in Table I assign three stars to it. These are α, β, γ Aris forming an obtusa angled triangle.

(b) Rohini has been assigned five stars by all the authorities in Table I. The identification by Burgess is in tune with this tradition. Abhayankar[5] mentions Rohini Sakata against Hyades. This star group is not mentioned by any of the authorities cited. α Tau is the Yogatara of Rohini naksatra.,

(c) Punarvasu, in many local traditions, consists of two stars and accordingly Burgess has identified them as α, β Gem. This is also the view expressed by Colebrook[2] and Abhayankar[5]. Saha and Lahiri have assigned four

stars to it viz α, β Gem and α, β CMi. In the five star composition in the form of a bow, the stars would be β, γ, λ Gem, β, α CMi. This configuration has been suggested by Varaha and Chandrasekhar. The Yogatara in all cases is β Gem.

(d) Pusya has been unanimously assigned three stars in Table I. The description as chalk powder suggests Praeseppe which is a galactic cluster too for away to be resolved by the naked eye. The description arrow suggests three stars in a line. These are δ Cnc, Praeseppe and χ Cnc.

(e) Magha has been unanimously assigned 5 stars in Table I. Burgess assigns four while Saha and Lahiri assign six stars to it. The extra stars are $\in, \mu$ Leo. By dropping the fainter of the two we should be left with $\rho, \gamma, \eta, \alpha, \in$ Leo as the five stars in Magha.

(f) Uttaraphalguni is to be identified with β, 93 Leo as per Saha and Lahiri.

(g) Visakha consists of four or five stars as per Table I. The identification by Burgess is more in tune with this. The same remarks hold good for Anuradha and Jyestha.

(h) The case of Purvasadha and Uttarasadha admit of more than one solution. This is reflected in the data by Burgess. In contains two star groups (couch) or four star groups (winnow). The elephant's tusk cannot be reconciled with winnow. I would personally prefer the four star grouping in the form of winnow as given by Chandrasekhar. The stars would be as identified by Burgess.

(i) Dhanistha has been assigned four of five stars in Table I. The four star grouping has been identified by Burgess while Sahā and Lahiri have assigned six stars to it. Dropping of $\in$ Del from this latter grouping will bring it nearer to the shape of a mardala.

With the modification to the Table II listings suggested above the identification can be brought nearer to the traditional shapes and number of stars as given in Table I. It would be easy to identify the naksatras with the help of star charts. There is a tendency among some writers to use the naksatra names for single stars in them such as Rohini for Aldebaran, Jyestha for Antares, Sravana for Altair and Abhijit for Vega. In view of the data in Table

I, this would seem as incongruous as Betalgeuse being called Orion or Polaris being named as Ursa minor. The stars mentioned above should be named in some other way with reference to the naksatra to which they belong, such as brightest, centre star etc.

The identification of the Yogataras can be made with the guidelines given in the Suryasidhanta and the Sidhantadarpana and the co-ordinates given in the Sidhantas. Samanta Chandrasekhar, after lifelong painstaking measurements has given the co-ordinates of the Yogataras to an accuracy significantly higher than the older Sidhantas when compared with modern data. A detailed account of the identification of the Yogataras is beyond the scope of this article.

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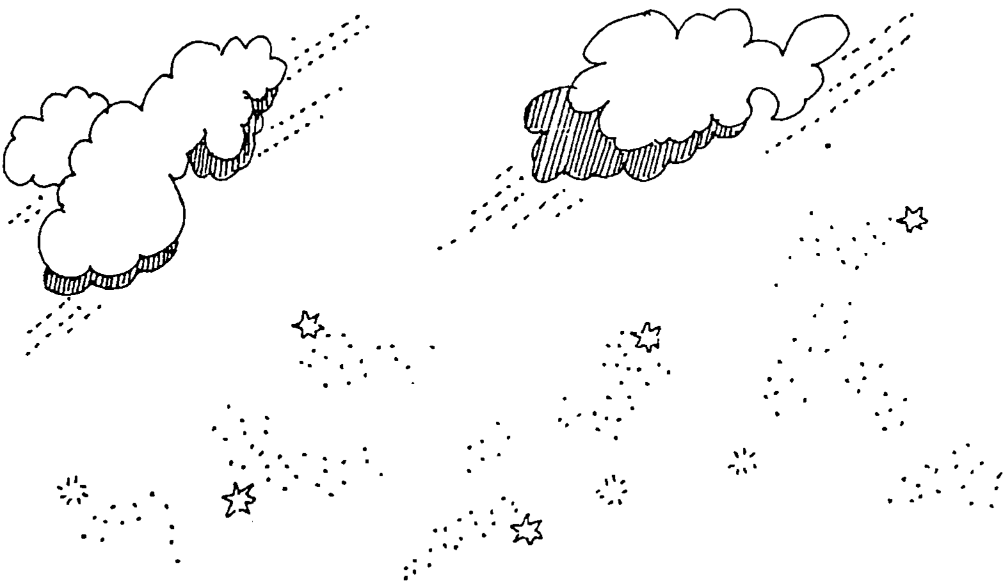


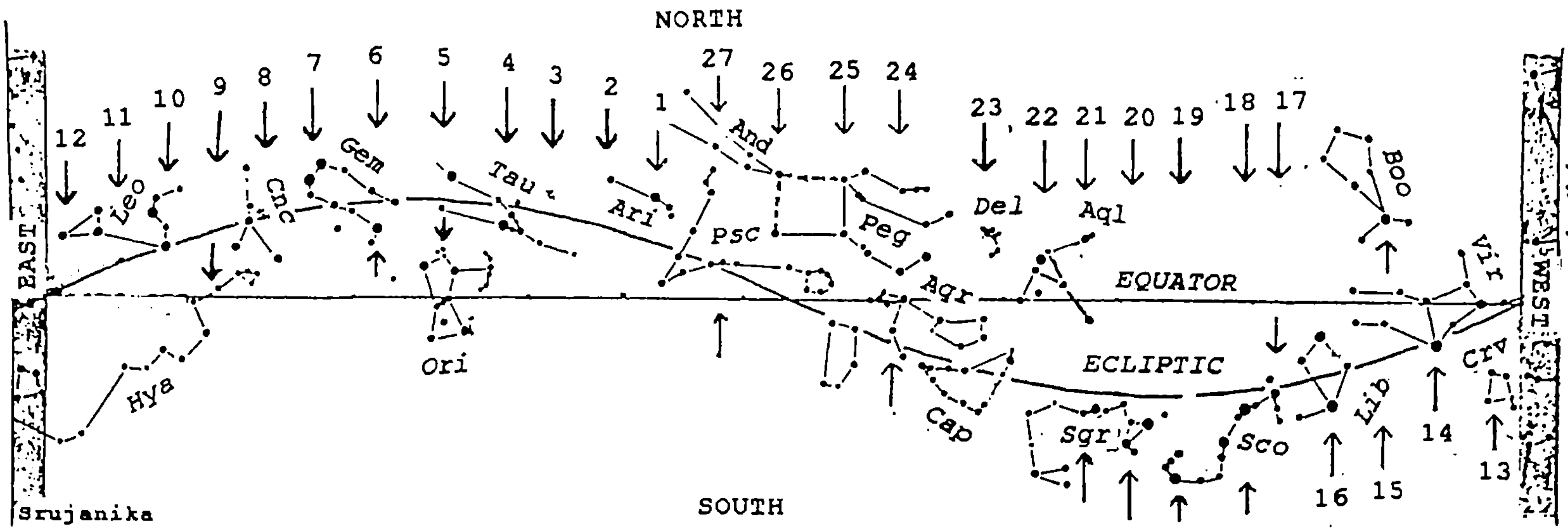
TABLE I. Shape of naksatras and number of stars

Sl.No.	Naksatra	Shape	No. of stars		
			(1)	(2)	(3)
1.	Asvini	Horses head	3	3	3
2.	Bharani	Triangle	3	3	3
3.	Krttika	Razor,flame, hoof	6	6	6
4.	Rohini	Cart	5	5	5
5.	Mrgasira	Deer's head, Cat's paw	3	3	3
6.	Ardra	Gem,Coral,lotus	1	1	1
7.	Punarvasu	House, bow	4	5	5
8.	Pusya	Arrow,Chalk powder	3	3	3
9.	Aslesa	Wheel,dog's tail	5	6	5
10.	Magha	House,plough,sal tree	5	5	5
11.	Purvaphalguni	Bed,bhara	2	2	2
12.	Uttaraphalguni	Bed, bhara	2	2	2
13.	Hasta	Hand	5	5	5
14.	Citra	Pearl	1	1	1
15.	Svati	Coral, manikya	1	1	1
16.	Visakha	Festoon, flag	4	5	5
17.	Anuradha	Lump of rice, snake	4	4	7
18.	Jyestha	Kundala, boar's tusk	3	3	3
19.	Mula	Lion's tail,conch	11	11	9
20.	Purvasadha	Couch, Winnow, elephant's tusk	4	2	4
21.	Uttarasadha	Elephant's tusk, winnow	3	8	4
22.	Abhijit	Singada, fire image	3	-	3
23.	Sravana	Arrow, Vamana	3	3	3
24.	Dhanitha	Mardala	4	5	5
25.	Satabhisa	Round jewel, gateway	100	100	100
26.	Purvabhadrapada	Two faced image, bhara	2	2	2
27.	Uttarabhadrapada	Couch, bhara	2	8	2
28.	Revati	Mardala, fish	32	32	32

(1) Sripati : Ratnamata (2) Varahamihira : Vrhatsamhita (3) Chandrasekhar : Sidhanta Darpana

TABLE II. Modern nomenclature of stars in the naksatras

Sl.No.	Naksatra	Burgess[3]	Saha and Lahiri[4]
1.	Asvini	β, γ Ari	α, β Ari
2.	Bharani	35,39,41 Ari	35,39,41 Ari
3.	Krttika	Pleiades	Pleiades
4.	Rohini	$\in, \delta, \gamma, \nu, \alpha$ Tau	α Tau
5.	Mrgasira	λ, ϕ', ϕ^2 Ori	λ, ϕ', ϕ^2 Ori
6.	Ardra	α Ori	α Ori
7.	Punarvasu	α, β Gem	α, β Gem α, β CMi
8.	Pusya	δ CnC	Praeseppe
9.	Aslesa	$\eta, \sigma, \delta, \in, \rho$ Hya	$\eta, \sigma, \delta, \in, \rho, \theta$ Hya
10.	Magha	$\rho, \gamma, \eta, \alpha$ Leo	$\in, \mu, \rho, \gamma, \eta, \alpha$ Leo
11.	Purvaphalguni	δ, θ Leo	δ, θ Leo
12.	Uttaraphalguni	β Leo	β,93 Leo
13.	Hasta	$\beta, \alpha, \in, \gamma, \delta$ Crv	$\delta, \alpha, \beta, \gamma, \in$ Crv
14.	Citra	α Vir	α vir
15.	Svati	α Boo	α Boo
16.	Visakha	i, α, β, γ Lib	α, β Lib
17.	Anuradha	$\beta, \delta, \pi, \theta$ Sco	δ Sco
18.	Jyestha	σ, α, τ Sco	α, Sco
19.	Mula	$\in, \mu, \xi, \eta, \theta, i, \chi, \upsilon, \lambda$ Sco	$\in \mu, \varphi, \eta, \theta, i, K, \lambda$ Sco
20.	Purvasadha	$\delta, \in$ Sgr or $\gamma, \delta, \in, \eta$ Sgr	$\delta, \in$, Sgr
21.	Uttarasadha	$\sigma, \in$ Sgr or ϕ, σ, τ, ξ Sgr	σ, φ Sgr
22.	Abhijit	$\alpha, \in, \varphi$ Lyra	-
23.	Sravana	γ, β, α Aql	α, β, γ Aql
24.	Dhanirtha	$\beta, \alpha, \gamma, \delta$ Del	$\beta, \alpha, \gamma, \delta, \in, \varphi$ Del
25.	Satabhisa	Aqr	Aqr
26.	Purvabhadrapada	α, β Peg	α, β Peg
27.	Uttarabhadrapada	γ Peg α And	γ Peg α And
28.	Revati	Psc	Psc



Location of the *Nakshatras:*

Sl.No.& Name	Constellation	Sl.No.& Name	Constellation	Sl.No.& Name	Constellation
1.Asvini	Mesha(Ari)	10.Magha	Simha(Leo)	20.Purvasadha	Dhanus(Sgr)
2.Bharani	Mesha(Ari)	11.Purvaphalguni	Simha(Leo)	21.Uttarasadha	Dhanus(Sgr)
3.Krittika	Vrisha(Tau)	12.Uttaraphalguni	Simha(Leo)	22.Sravana	Garuda(Aql)
4.Rohini	Vrisha(Tau)	13.Hasta	Hasta(crv)	23.Dhanistha	Dhanistha(del)
5.Mrigasira	Kalpurush(Ori)	14.Chitra	Kanya(Vir)	24.Satabhisaj	Kumbaha(Aqr)
6.Ardra	Kalpurush(Ori)	15.Swati	Bhutesha(Boo)	25.Purva-bhadrapada	Pakshiraj(Peg)
7.Punarvasu	Mithuna(Gem)	16.Vishakha	Tula(Lib)	26.Uttara-bhadrapada	Pakshiraj(Peg) Andromeda(And)
8.Pusya	Karkata(Cnc)	17.Anuradha	Vriscika(Sco)	27.Revati	Mina(Psc)
9.Aslesa	Vasuki(Hya)	18.Jyestha	Vriscika(Sco)		
		19.Mula	Vriscika(Sco)		

VARIABLE STARS AND AN INDIAN AMATEUR ASTRONOMER

Amalendu Bandyopadhya

For millenia, poets and scientists believed that the stars are constant and unchanging. Shakespeare has Romeo say that Juliet is more constant than "the fixed stars". But we now know that the stars are changing, slowly evolving as they consume their fuels. If we monitor the brightnesses of certain stars, we find that many change with time. These are known as variable stars.

At the fag-end of the sixteenth century, a German astronomer named David Fabricius was involved in studying the sky. On August 13, 1596, he discovered that the star Omicron Ceti is variable in brightness, sometimes fading from third magnitude to invisibility. Not until almost 1640 did astronomers realize that its variations are periodic, repeating with a period of 332 days. That star, now known as Mira, meaning "wonderful", was the first-known variable star.

There is a star called Algol. The name derives from Al Ghul, the name given to this star by the ancient Arabs. Literally, Al Ghul means "changing spirit". To the Hebrews, Algol was Rosh ha Satan, "Satan's head". To the ancient Chinese, it was Tseih She, meaning "piled up corpses", known popularly as the "demon star", Algol time and again in different cultures connotes something grotesque and macabre. Why ? Could it be that ancient people of many different lands noticed that at times Algol's brightness rapidly drops to one-third its normal value ?

No one knows for sure, because the first existing record of Algol's occasional change in brightness was not made until 1670 by the Italian astronomer Montanari. Twenty-five years later, Maraldi also noticed Algol's strange behaviour, but the astronomical community did not consider Algol seriously until 1783. In May of that year, a letter from the President of the Royal Society to William Herschel told the discovery of the periodicity of Algol's changing brightness. This discovery had been made during the late months of 1782 by an eighteen-year-old John Goodricke. He found that every 2 days and 21 hours, Algol completed a cycle of change in brightness.

To some, John Goodricke may be thought of as a tragic figure. He was unable to either hear or speak. His life was short, snuffed out at twenty-two. But, on the other hand, he had a fine mind and the ultimate playground in which to exercise it — the universe. Besides the periodicity of Algol, he discovered the variability of two other stars : Beta Lyrae and Delta Cephei. For his accomplishments, he was awarded a medal by the Royal Society and was elected a Fellow of the Society only two weeks before his death. Goodricke published his data on Algol in the "Philosophical Transactions of the Royal Society". In the paper's conclusion, he offered the explanation that the variation in Algol's brightness resulted from an eclipse by a body revolving around it. Goodricke died at the agê of 22, but his discovery ensures his place in the history of

astronomy. Since 1784, almost 1000 stars like Delta Cephei, have been discovered. Known as Cepheids, they are the most important kind of variable star.l Cepheid variables are giant stars. The most rapidly varying complete a cycle — bright, faint, bright — in about 2 days, whereas the slowest take as long as 60 days. A plot of a variable's magnitude versus time, called a light curve, illustrates this periodic variation. Some Cepheids change their brightness by only 0.1 magnitude, whereas others change by as much as 2 magnitudes.

Giant stars are rare, and giants that are Cepheids are even more rare. Nevertheless, some familiar stars are Cepheids. Polaris, for instance, is a Cepheid with a period of 3.9696 days and an amplitude of only 0.1 magnitude.

Variable star astronomy is certainly one field in which an amateur astronomer can make significant contributions to science. One of the most valuable fields of observation is perhaps that of variable stars and here amateur observations are not only important, but frequently essential. The several types of variables all offer clues to the detailed physical nature of stars, but only if significant numbers of them are systematically monitored. A precise knowledge of each variable's behaviour i.e. its range and period of fluctuation, the characteristic shape of its light curve, depends on very large number of observations, preferably by a variety of different nobservers.

In general one amateur astronomer's procedure should be as follows : one should observe a selected star as frequently as poossible, always with the same telescope or binoculars (i.e. the same magnification) to obtain a uniform impression of stellar brightness. The magnitude of the target star may be estimated very carefully. Of course the basis of the estimate is comparison of the variable with other stars in the telescopic field whose magnitudes are known and trusted as invariable. Dates, times and magnitudes should be recorded and may eventually be plotted to show a graphic profile of the behaviour of the variable star. And the most important final step should be, of course, to report this information to researchers who are in a position to make use of it. An international centre which coordinates such observations is the American Association of Variable Star Observers — (AAVSO). This organization instructs new contributors on the details of the standard reporting form and usually they also assess the quality of the beginning observer's contributions, with the sole objective of assisting an amateur astronomer in achieving a useful level of technique.

Variable stars are listed in order of discovery within a given constellation. The first is designated R (e.g., R - Ori), the next S, and so on to Z. After that, two letters are used, starting with RR, RS, to RZ, then SS to SZ and so on, until ZZ is reached. Then comes AA through AZ, BB through BZ, and so on to QZ. The J is never used because of possible, confusion with I . This gives a total of 334 stars per constellation. Beyond that, numbers, starting with 335, preceded by a V (for variable), are used (e.g. v 335 - Ori, V 336 - Ori, etc.)

Variable stars are divided into classes depending, in the first place, on the shape and appearance of their light curves, but other properties must be considered to complete classification, if members of one class are to be represented as

physically the same, but different from members of other classes. Among the additional criteria are the absolute magnitude and spectral type i.e. the position of motion and position in the galaxy. However, since the spectra of only about 25% of variable stars are known, more weight is given to the appearance of the light curve. Further difficulties in classification are introduced because there is still no general physical theory available for the causes of the different kinds of light change in the intrinsic variables. The classes are normally named after those stars which exhibit typical class properties.

In principle, variables are divided into two large main groups (i) the intrinsic and (ii) the extrinsic variables. With the intrinsic variables or true variables, the light changes are caused by actual temporal changes in luminosity, where the radius of the star, the effective temperature and its spectrum also change. The extrinsic (optical) variables, on the contrary, remain constant as regards luminosity, radius and spectrum, they are double stars and the cause of the changes is due to either periodical eclipse of one component by the other (they are called eclipsing variables) or a changing size of the visible luminous surface (they are called ellipsoidal variables). About 80% of the known variables are intrinsic variables.The intrinsic variables are divided into two groups : (i) pulsating variables and (ii) erupting variables. The majority (about 90%) of intrinsic variables are pulsating variables i.e. their light change is produced by more or less regular pulsations of the radius as well as by changes in the effective temperature. In this group, there are variables in which the light changes take place with great regularity, so that over a long period it is possible to determine the time of the maximum and minimum magnitude. Under this category of variable stars falls (a) RR - Lyrae stars (b) Delta - Cephei stars (c) Mira star (d) Delta Scuti stars etc.

Among the erupting variables, on the nother hand, the light changes are mainly caused by one or more periodical eruptions, i.e. increases in brightness associated with the ejection of matter, which affects the whole star or only the stellar atmosphere. For this main - sequence variables, the division into groups is based on the strength of the outbursts. Under this category of variable stars, falls (a) Novae (b) Supernovae (c) RW Aurigae stars (d) UV - Ceti stars etc.

The extrinsic variables are divided mainly into groups : (i) eclipsing variables and (ii) ellipsoidal variables.Variables have been found not only in our Milky Way Galaxy, but also in great numbers in other galaxies. Cepheid variables have played an important role in determining the distances of these galaxies.

A list of all known variable stars is that prepared by the Soviet astronomers Kukarkin, Parenago, Efrenov and Cholopov under the auspices of the International Astronomical Union (IAU) every ten years, with annual supplements and published as the General Catalogue of Variable Stars. It contains the classification of the stars, the position, the shapes of the light curves, the range of magnitude and the spectral type. Maps necessary for the identification of weak variables are dispersed in the literature.

The promotion of the science of astronomy was not the aim of the British rulers in India. The optical telescope was discovered in the western world in the

year 1609 and its extensive use by Galileo revolutionized the study of astronomy. Very few Indians at individual level were influenced by such revolution even in the nineteenth century and it was almost a rare event for an academically less equipped person. In this state of indigenous science of astronomy, it may be singular to find a man born and brought up in a remote village of undivided Bengal during the British rule, far removed from all higher educational activity and the incluence of imported western civilization, silently threading his way into such a difficult science as observation of variable stars. It may be a unique experience to find a man sincerely striving to acquire knowledge for its own sake, under difficulties less enormous than the boldness of his attempt. Radha Gobinda Chandra is that man. Not many of us, even those with an interest in astronomy, may be acquainted with the name of Radha Gobinda Chandra, who is credited to be the first person in India, as one of the pioneers in the study of variable stars.

Radha Gobinda was born in July1878 in a small village of Jessore district, now in Bangladesh. His academic career was brief and simple. He did not even proceed as far as the Entrance examination (at present called the school final examination). At the age of 22, he joined the Jessore Collectorate Office as a podder (coin tester belonging under class IV staff) with a monthly salary of Rs.15/- only. He used to spend his day in the office, but coming back home, his passion was only sky - watching during the night. Unaided and surrounded by practical difficulties, what patient labour he must have undergone in his early days to observe and work out practically the astronomical elements of the celestial objects in the sky. Night after night passed away in the all - absorbing business of sky - watching. In the year 1912, out of savings from his very small income, Radha Gobinda could finally purchase a 3 - inch refracting telescope from London at a cost of Rs.160/- only and with the aid of this telescope, he started measuring accurately the variations in brightness of variable stars with utmost seriousness and his astronomical findings on variable stars became a treasure of much significance. And who were the regular recepients of such observational findings from him ? Most famous astronomical organisations like Harvard Observatory of America (i.e. AAVSO), British Astronomical Association and Lyon Observatory of France used to receive regularly such observations on variable stars from Radha Gobinda. A huge number of observations made by him can still be found in the archives of Harvard, British Astronomical and Lyon Observatories. From old records, it appears that contemporary astronomers of top class western astronomical organisations used to attach great importance to the observations made by Radha Gobinda and great recognition of his valuable works came from abroad only.

After independence, Radha Gobinda with his family migrated to a place near Calcutta, from erstwhile Pakistan and at the good old age of 97, he expired on 3 April 1975. It is really unfortunate that the man who won recognition for his valuable works on variable stars in astronomy from first grade astronomical organisations of the western world, remained almost unknown to his own countrymen even after 28 years of independence. Radha Gobinda Chandra may be regarded as an Indian amateur astronomer of outstanding merit.

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THE BIG BANG AND AFTER

Lambodar P. Singh

A deep sense of wonder and awae has always driven man to ask questions relating to the innumerable aspects of the pohysical and phenomenal world, since the time immemorial. Of all these questions, the ones relating to the "Origins", the origin of the stars and the planets to those of life and the Universe, have not only found preminent place in man's thought schedule but seem to have become an obsession with him. Undaunted by the enormity of the task, he has mused himself with concepts and models, if only to break them with new insights and build again. Such intellectual and inspired efforts have handed us down, what we call, "standard models", summarising our ultimate understanding of various aspects of the phenomenal world. Drawin's theory of evolution, Electro-weak unification, Tectonic theory of continental drift and the Bigbang creation of Universe are examples of such standard models.

The basic impact of these models have been to raise a sense of assurance in man that this seemingly incomprehensible world, after all, astonishingly though, is comprehensible and makes him assert, following Einstein, "pure thought can grasp the reality". The secret of this "comprehensibility" is the recognition of simple unifying principles operative in myriad of diverse phenomena. This understanding has led to the present intense efforts in search of one all unifying principle operative, perhaps, at the time of creation of the Universe. This undertaking, one may note with pleasure, is also precisely the one that stirred the imagination of the seers of our land ages ago, when they sang.

"That knowledge alone is true,
Telling us of one undying principle in all the hue"

Bhagbat Gita, Ch. 18, Sloka 20

As we prepare here ,to deal with one standard model conceming the origin and evolution of the Universe, let us first clarify what Universe means to us. Universe is the all embracing whole, it includes all space, even infinity; all time, past and future; all things, material and all other; all information, true or false; all life, all intelligence. There is no "outside" to it, no edge to it. As Fred Hoyle would like to put it.

"The Universe is every thing,
both living and inanimate things,
both atoms and galaxies,
and if spiritual exists,
as well as the materials,
of spiritual things also
and if there is a Heaven
and a Hell
Heaven and Hell too,
for by its nature, the Universe
is the totality of all things".

Do we know anything else about our Universe excepting that it includes every thing ? Yes, the modern scientific tools have enabled us to "look" out and explore the pohysical aspects of the Universe. As far as we know, the Universe is big with a radius of about 21 x 10^9 light years and mass around 2.5 x 10^{54} Kg. (10^n = 10 x 10 x10 ....n times). It contains about

10^{11} galaxies with each galaxy, in turn, containing about 10^{11} star. Needless to remind ourselves that one of these stars, the Sun, has a planetary system attached to it and we have built our home, culture and civilisation on only one of the planets, called Earth, belonging to this solar system. Despite the presence of so many galaxies, the Universe is rather empty with an average density of 2 x 10^{-26} Kg/m^3 i.e about 1 atom per 16 m^3 space. (10^{-n} = 1/$10^n$$\cdot$$m^3$ = Cubic metre). The chemical composition of the Universe is roughly as Hydrogen 92%, Helium 7.8%, Oxygen 0.06%, Carbon 0.03%, Nitrogen 0.008%, Neon 0.007%, Iron 0.003% and the rest 0.09%. The space pervading the Universe is isotropic, homogeneous and transparent. The Universe is rather cold with a temperature of 2.9° K. Overshadowing all these details, however, is the astounding observation made this century in 1929 by Edwin Hubble that the Universe is expanding ! The galaxies move away from each other and farther a galaxy, greater is its velocity of recession. The expansion velocity is increasing at the rate of 14 Km/sec for each million light years. (Light year is the distance travelled by light in one year which is about six million million miles). That's about all we know of our Universe at this moment.

It is with these information listed above that any viable model of the origin and evolution of the Universe must contend with. It is precisely on this count, the "hot bigbang" model of Gamow, propounded in 1940 regarding the origin of the Universe, seems to have won the day, at least for the npresent, as against steady state theory of Hoyle and Narlikar. The galaxies, for example, are moving apart because they were thrown apart by some sort of explosion in the past, the Big Bang that is. Thus, the Universe has a beginning. It began with a "Bang" followed by continuous expansion. Space, time, matter and events all originated only after this first cosmic event, the Big Bang.

Immediately, after the Big Bang, the Universe was very small, very hot very dense with primordial force and particle of a single kind. The Universe then continued to evolve to reach the present state with the dynamics controlled by the gravitational interaction as per the dictats of the general theory of relativity of Einstein. The evolutiuon of the Universe divides itself to five significant phases that we undertake to describe now.

The Phase- I may be called very Hot Era. This era concerns the period immediately after the Big Bang. The Universe is then only 10^{-44} seconds old. Its temperature is 10^{32} °K, radius 10^{-5} metre and density 10^{96} Kg/m^3, exactly the way stated earlier. (1° K = 1 degree Kelvin = -273° celcius).

In Phase-II. the Hot Era, the Universe is 10^{-36} seconds old. Its temperature is 10^{28} °K, radius 0.1 metre and density, still high, 10^{80} Kg/m^3.

As we move to phase-III, the Luke Warm Era, the Universe has become 10^{-20} seconds old with a radius reaching the value of 10^3 to 10^7 metres and temperature in the range of 10^{24} °K-10^{20} °K.

In the fourth phase, the Cold Era, the Universe becomes 10^{-10} seconds old and has a temperature 10^{15} °K. The Universe, still, is so dense that even radiation can not proceed through much of a distance without getting scattered. That keeps the whole material content of the Universe in thermal equilibrium.

There are some small number of neutrons and protons moving around. But as the Universe gradually cools through a temperature of ${}_{10}9^{\circ}$ K the nuclear particles like neutron and proton bind themselves to form light nuclei like deuterium, helium, lithium etc., but most abundantly helium.

This process of nucleosynthesis comes to a stop as the Universe reaches about four minutes of its existence. But at this time, the cosmic matter still exists in plasma state consisting of ions and charged particles, making the whole universe opaque. Its radius now is about 10^{18} m and density ${}_{10}3^{\circ}$ Kg/m^3. This state continues for nearly 700,000 years with nothing spectacular happening. As the universe approaches 10^6 years of age with its temperature around 35 x 10^3 °k, formation of neutral atoms begins. With the disappearance of ions and charged particles, the universe becomes transparent, must the same way opaque medium of muddy water contained in a glass becomes transparent with the settling down of the impurities. Primordial "Fire-ball" has died out. Cold, transparent, low density Universe begins.

The fifth and the last phase, called very Cold Era begins when the Universe is nearly 10^9 years old. Its temperature is about 10 °k and radius nearly 10^{27} metre. Gravitational force starts playing its role in a manifest fashion. Proto-galaxies are formed as large mass of 10^{42} kg of cold clouds consisting largely of hydrogen and helium. Further condensation brings about smaller but denser "drops" of mass of 10^{28} -10^{32} kg. There are the proto-stars. Gravitational energy release in proto-stars enables nuclear burning of H and He. Heavier nuclei start getting formed. Gradually short-lived proto-stars expire in dramatic explosion. From its "ashes" evolve the second generation stars. The second generation stars eventually make room for the third generation ones, the group to which our sun belongs. Proceeding further with time, the stars are seen to evolve and near some suitable stars chemical and biotic evolution finds a home. Life springs up spontaneously, at some corner, a master stroke from the Master-Craftsman. The story of evolution of life culminating in intelligence is the story extraordinary of another standard model of ours, richly deserving a separate narration by its own right.

This roughly is a sketch of the 12 x 10^9 years long history of the evolution of the universe covering the period from the initial Big Bang till today.

"If God, who has made our world a perfect mechanism, has atleast conceded so much to our imperfect intellect" that we have got the origin and evolution of the universe right, if the laws of physics operating "now" and "down-here" were also operative "then" and "up-there", we might as well speculate on the future of the Universe. We are confronted with two possibilities here. If the Universe is flat, it must continue to expand forever. If the Universe is spherical, it would expand to a limit of radius about 4 x 10^{26} metres and 66 x 10^9 years old, only to contract thereafter to a Big Crunch in as many years. Eitherway, having little at stake personally, either from Big Bang or the Big Crunch, we can amuse ourselves by this captivating story of the Universe. Better still, if we can make our contribution to the understanding of this ever-unfolding drama of Nature, in however small measure it may be.

Department of Physics
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AMATEUR ACTIVITIES

ORISSA RENEWABLE ENERGY DEVELOPMENT AGENCY

S-59, Mancheswar Industrial Estate,
Bhubaneswar

OBJECTIVES :

The Renewable Sources of Energy are of great importance for making up acute shortage of Energy of Orissa. The main objectives for development of renewable sources of energy are :

i. Development of renewable energy sources wherever they are technically and economically viable.

ii. Improvement of renewable decentralized energy sources for rural population in particular.

iii. Development of rural, urban, backward and hilly/ tribal areas for use of locally available decentralized renewable energy sources.

iv. Creation of employment opportunity specially for women and other disadvantage groups.

v. To check environmental degradation caused by deforestation.

ACTIVITIES :

Orissa Renewable Energy Development Agency (OREDA) executes, monitors, plans, co-ordinates and evaluates various renewable energy sources in the State. The following are the major activities for development of renewable sources of energy in the State of Orissa.

a. National Project on Biogas Development (NPBD)
b. Community Biogas Plants/ Institutional Biogas Plants (CBP / IBP)
c. National Programme on Improved Chullah (NPIC)
d. Solar Photovoltaic System (SPV)
e. Solar Thermal Extension Programme (STEP)
f. Wind Power/ Aero Generation and Wind Mapping
g. Wind Mill
h. Urjagram
i. Biomas
j. Energy Audit
k. Research & Development (R&D)
l. Integrated Rural Energy Planning Programme (IREP)
m. Appropriate Rural Technology (ART)

" ENERGY FOR ALL : ENERGY FOR EVER "

Please Contact : *Sri U. P. Singh, I.A.S.*
Chairman-Cum-Chief Executive, OREDA

AMATEUR ASTRONOMY : A VEHICLE FOR SCIENTIFIC TEMPER

L. Satpathy

When I was at Mc Gill University, Montreal in the year 1980 as a visiting professor, I was asked by a post doctoral fellow from Israel, if it was true that majority of Indians remain sitting with half closed eyes oblivious of the things, beings and happenings around them. What was implied by him was that, whether most of the people in India are unworldly, least bothered about material prosperity and are solely concerned about "nirvan or mokshya" which is supposed to be a phenomenon happening after death. This incident is by no means an isolated one, but a symptom of a general notion held by the west about India. A superficial view of Indian philosophy gives the impression that it attributes supreme importance to Mokshya which can be attained by meditation. Such a conclusion is quite mistaken, as it assumes the tip of the iceberg as the iceberg itself, and ignores the preceeding several steps of evolution which are prescribed to be attained through very active hard work enjoyed by "Karmayoga". It is a queer fact of history that, although India and few other countries had farely advanced ancient civilization, several tens of centuries before the advent of Christian era, modern science was born in Europe around sixteenth century, which led to the scientific and industrial revolution in which our country could not be an active partner. This phenomenon puts us way behind the western world, although throughout the history of the world India was a rich and leading nation in all spheres of human endeavaour.

To-day, science has become an integral part of human life. It has pervaded into every spheres of human activity. It is now an acknowledged fact that the nation which will dominate the world must be the most advanced in science. The importance of science for a modern nation cannot be overemphasised. It is now becoming clear that a society that function effectively, understanding of science and scientific method, is a basic requirement of all. The high tech society of future would become so complex, its various facets would become so integrated that, intutive reasoning, unsupported by knowledge and logical thought would lead to chaos. It is difficult and it would be still more difficult with passage of time, to make sense of the modern world without knowing something of modern science. People cannot participate meaningfully in such a world unless they can think quantitatively, supported by a basic understanding of science and scientific enterprises. The citizen of such a society cannot react to the policies and programmes of the Government and guide it properly. We have not been able to eradicate illiteracy in our country. In the western world, people have started worring about scientific literacy for the entire population. It is being felt that without complete scientific literacy, the growth of the society in the twenty first century will be greatly hindered which would adversely affect the progress. Therefore, it would be grave error not to give due importance to the general awareness of science, science education and above all the growth of scientific temper, otherwise, we would be creating a physically handicapped society which would not be able to compete and sustain in future.

Therefore, creating scientific temper and general awareness of science is of paramount importance. How can it be done in the most effective way ? It can be done by arousing curiousity about science in the people. Out of all disciplines in science, one

which causes maximum wonderment and curiousity in all persons, irrespective of age, education, sex, cast, colour and creed is the astronomical phenomenon. There is nobody who has not wondered at the myriads of twinkling stars, blue expanse of the limitless sky, red and scarlet twilights and fascinating phenomena involving Sun, Planets, Moon, Comets, Nabulae and falling Meteorites etc. The first and foremost question that comes to the mind of a child is that, why the moon does not fall to the earth like an apple from a tree. Such wonderment has set the prehistoric man into thinking about physical phenomena and would continue to do so till eternity. Hence in astronomy lies the greatest potential for arousing the curiosity in man about science. Therefore, this discipline of astronomy should be used as a vehicle to creat general awareness and scientific temper in the society. It must be remembered that the true understanding and proper comprehension of a single phenomenon by a person raises his general conciousness for appreciation of other apparantly unrelated phenomena. The science of astronomical phenomena involves many areas of physics like mechanics, gravitation, nuclear physics, particle physics, optics and cosmology etc. Thus, for an over all awareness of science and creation of a scientific temper in all section of population, astronomy can be used as a useful vehicle.

It is with this motivation, we have established the Samanta Chandra Sekhar Amateur Astronomers' Association (SCAAA) in Orissa in 1993. A significant part of the impetus in this regard has been obtained from the life of Samanta Chandra Sekhar (1835-1904), the greatest astronomer of Orissa who rightly belongs to the same class of Indian astronomers as Arya Bhatta, Barahamihir, Brahmagupta and Bhaskar. It is a pity that although the famous international science journal "The Nature", comparing him with Tycho Brahe of Europe, unreservedly assigns a higher position and calls him a modern Tycho, his name is hardly known outside the boundary of Orissa. As mark of our deep reverence and love for this illustrious astronomer, we have named our Association after him.

In to-day's world, the generation of wealth and economic prosperity of a nation are more strongly governed by the creation of new ideas in science and technologies, rather than by the natural resources it possesses. It is a fact that the values, norms and ideals admired and held supreme in the society are imbibed by its members. Keeping this in view, SCAAA is aiming at a mass movement for an upsurge of scientific spirit, fervour and enthusiasm for awareness and appreciation of science in the society.

Institute of Physics
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SUN, MOON AND PLANETS - 1995

Bharat R. Trivedi

This unique chart shows position of Sun, Moon and all the five naked eye planets in the sky on any date throughout the year 1995. Such a chart would prove to be a very useful and handy reference to anyone who loves star gazing.

The chart shows "elongation" of moon and planets from Sun against background of zodiacal belt in the sky which is along the ecliptic i.e. the plane of earth's orbit around Sun. The term "elongation" means the angular distance of moon or a planet from Sun measured in east - west direction. To an amateur the chart serves as an excellent planner for night sky observation. Inclusion of moon's elongation in the chart helps both, the moon observer as well the deep sky observer in planning their observation schedule. Just put a ruler along a date line and you can read which planet is in which zodiac, when it rises or sets, what is the age of the moon and many other things like conjunction, opposition etc.

Looking at the chart we find that it is vertically divided by a central thick line. This is Sun line. As the year progress we notice that the Sun is travelling through the zodiacs from Capricornus (CAP) in January to Sagittarius (SGR) in December. Similarly the paths of moon and the planets are also plotted for the year. Ech object in the sky is identified on this chart by their respective signs which are explained at the end of this article.

As we observed earlier, the chart is bisected vertically by the Sun line. The portion on left of Sun shows evening sky from west to east at sunset time and that on right of Sun line shows morning sky from east to west at sunrise time. We know that the angular distance between east and west horizon is 180 degrees. This angular distance of 180 degrees is expressed as 12 hours of time for the convenience of the reader. This is simply because our earth rotates from west to east through 180 degrees in 12 hours and as a result of which we see all stars and planets in the sky moving from east to west at a rate of 15 degrees per hour i.e. 180 degrees in 12 hours. Thus on this chart the Eastern elongation (object east of Sun) is shown on left of Sun line and the Western elongation (object west of Sun) is shown on right of Sun line as X axis grid in hours of time from 0 to 12 hours on either side of Sun. The dates are shown as Y axis grid on extreme left of the chart. We also observe that the slant zodiac bands are named on extreme right and at bottom of the chart.

With this much explanation of chart design, let us see how we can use it for knowing sky of any date. Suppose we want to know observing prospects on 10th May, 1995. For this we read along the date line 10 May and find that Sun is in Aries, about to enter Taurus in a few days. Planet Mercury is in Taurus at about 1.6 hours eastern elongation meaning that Mercury is in evening sky and can be seen at 1.6 hours x 15 degrees = 24 degrees altitude above western horizon at sunset time. This also means that planet Mercury will set about 1.6 hours after sunset. On the same date line we see that the planet Mars is at 6.5 hours eastern elongation in zodiac Cancer preparing to enter Leo in a few days. Thus we see that Mars is almost overhead at sunset time and we can

observe it till midnight. Similarly we find the waxing moon at 8 hours eastern elongation in Leo. It's age being 8 hours x 1.25 = 10 days after new moon. Now looking at the morning sky we find Venus at 2 hours western elongation in zodiac Pisces. This means Venus rises 2 hours before sunrise and will attain an altitude of 2 hours x 15 degrees = 30 degrees above eastern horizon by sunrise time. Looking further in morning sky we find that the ringed planet Saturn is along Aquarius - Pisces border at about 3.5 hours western elongation rising 3.5 hours before Sun. Similarly we find planet Jupiter to be at 10.5 hours western elongation in zodiac Scorpio. This means planet Jupiter rises 10.5 hours before sunrise or in other words, it rises 12 - 10.5 =1.5 hours after sunset and can be observed throughout the night. Thus we have complete picture of the sky at a glance for any date of the year with the help of this wonderful chart.

Those of you interested in observing remaining three telescopic outer planets viz. Uranus, Neptune and Pluto may note that planets Uranus and Neptune remain together along Sagittarius-Capricornus border within five degrees of each other while Pluto wanders along frontal edge of Scorpio throughout the year 1995. For exact position please refer to ephemeris published by Positional Astronomy Center, Calcutta.

One of the most interesting celestial events of the year 1995 will be the Total Solar Eclipse that will occur in the morning hours of 24th, October (Diwali Day). The path of totality will run from Rajasthan in the north-west to Gangetic deltas of Bay of Bengal. Astronomers from all over the world will gather on totality path to observe this rare event. We shall write about it in more detail in separate articles in near future.

Star gazing is an inexpensive, entertaining and highly educative hobby. To develop this hobby all you need is a pair of eyes, an inquiring mind and love for the nature. With this new hobby you will soon discover many amazing facts about universe and our existance. Wish you a very entertaining star gazing in the new year.

The signs used on this chart are :-

SUN	MOON	MERCURY	VENUS	MARS	JUPITER	SATURN
☉	○	☿	♀	♂	♃	♄

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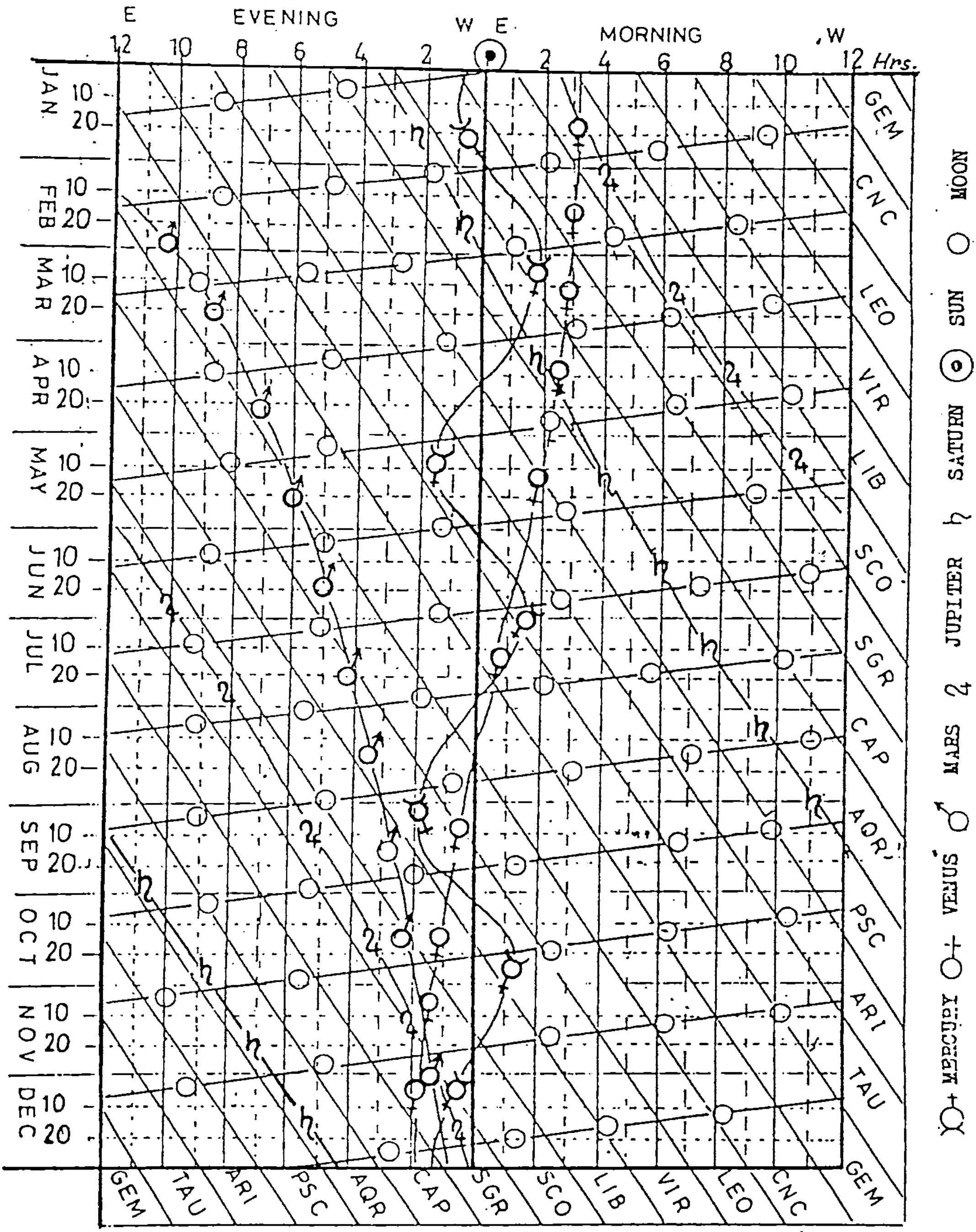
About the author :

The author is an amateur astronomer interested in popularising astronomy. He is an engineer by profession, working with Jyoti Ltd., Vadodara.

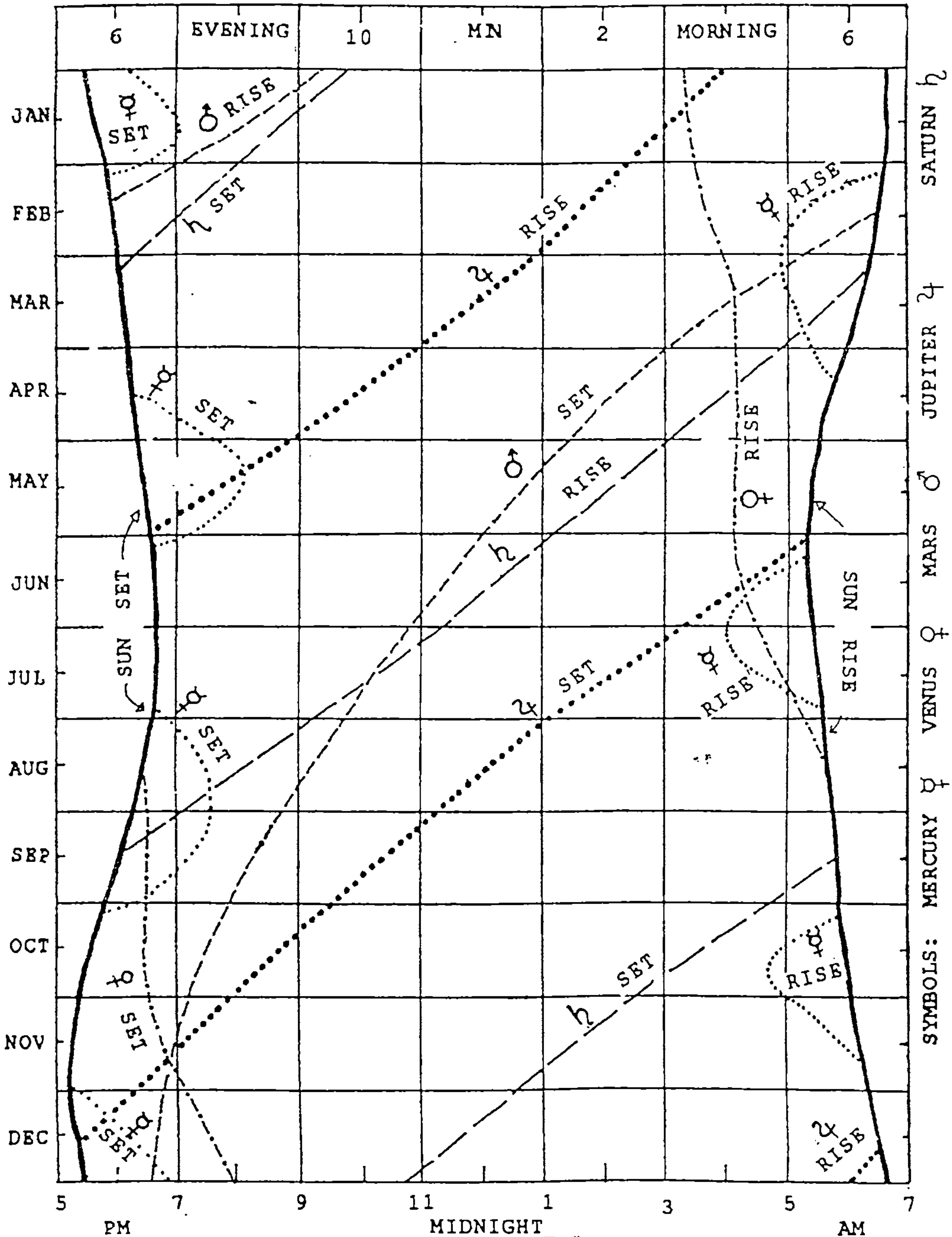
1995

SUN, MOON AND PLANETS



BHARAT R. TRIVEDI, 34/199 Ellora Park, Vadodara 390 007.

Nocturnal Rising and Setting Time of Planets during 1995



Dr. Nikhil Mohan Pattnaik, SRUJANIKA, Bhubaneswar

SKY CROSSBOW - AN INTERESTING INSTRUMENT

Bharat R. Trivedi

There is a beautiful relation found in Geometry text book. This is $S=R\theta$ where θ (pronounced as "theta") is measured in Radian. 1 Radian is equal to $180/\pi$ degree. We can rewrite this relation as (Refer Fig-1)

$S = R\,\theta$

Or $S = R\text{x}\ \frac{DEG \times \pi}{180}$

Or $S = R \times \frac{DEG}{57.3}$

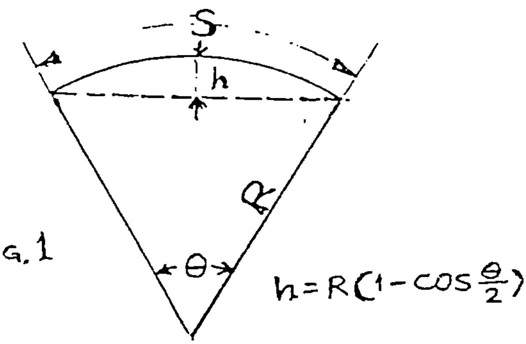


Fig. 1

This last version, S = R x (DEG/57.3), implies that for an arc having a radius of 57.3 length unit, the number of degrees in the arc will equal the number of length units in that arc. In other words S = DEG if R = 57.3. Well, this is wonderful ! If we take a 30 cm ruler and bend it to a radius as 57.3 cm then each centimeter mark on the ruler bow will represent 1 degree of angle !

Making use of this innovative idea, we can build a very useful instrument to measure angular distances in the sky. Let us build one. We will need following easily available material to build our "SKY CROSSBOW".

* One 30 cm Ruler (metal, plastic or wooden)

* One 60 cm long tube (aluminium tube used in TV antenna is ideal, but any similar stiff and light tube would do)

* Approximately 1 mtr long nylon string

* Two wooden plugs 4 cm long to fit into tube ends

* Two wood screws 2 cm long

<u>Construction :</u>

* Drill 4 mm diameter holes at 5 mm, 150 mm and at 295 mm markings on the ruler along its centre line.

* Square the ends of the tube and fix wooden plugs at both ends flush. Use resin cement if required.

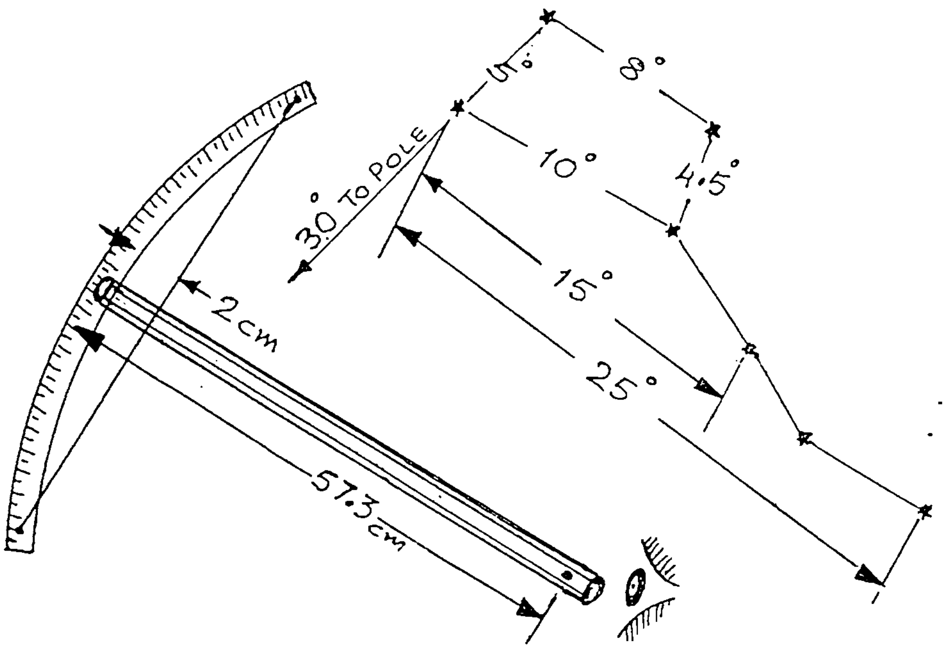
* Choose better end of the tube and mark at 2 cm and 57.3 cm.

* Using a wooden screw, fix the ruler through the middle hole to the chosen end of the tube.

* Tie the nylon thread along two extreme ends of the ruler using previously drilled holes and stretch in such a way that the ruler is bent towards the tube in a bow shape. Bending of ruler should be such that the thread forming chord of the bow arc align with 2 cm marking on the tube.

* Fix another wood screw through 57.3 cm marking on the tube such that the prutruding end of the screw serve as centre of the ruler bow arc.

Now our SKY CROSS BOW is ready for use. It looks like the one shown in Fig. 2 below. Each centrimeter mark on our sky crossbow now represent 1 degree of angle and each millimeter mark represent 0.1 deg. With little practice you can very accurately measure angular distance between two stars now. For your practice session, given below are the angular distances of various stars in famous constellation Ursa Major (the Saptarishi). Besides, you may also use the sky cross bow for marking out angles on large flat surfaces.



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Note :

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AN IMPROVED GNOMON

Ved Ratna

Abstract : During a project work done by a group of students at senior secondary state under the guidance of the author, the vertical pillar kind of gnomon has been improved upon. Whereas the traditional gnomon can measure altitude of Sun with a precision of about 0.25 degree, the improved done can measure it with a precision of about 0.05 degre, by the observation of its shadow only. It also enables to make the plane surface on which it is placed accurately horizontal.

The Traditional Gnomon : The traditional gnomon is a shadow instrument which casts its shadow by sunlight on an appropriate surface for studies related to sun. It may take several shapes :

1. A vertical pillar casting its shadow on a horizontal plane surface.
2. A straight edge parallel to axis of earth casting its shadow on a hori zontal or vertical plane surface.
3. A straight thin rod parallel to axis of earth casting its shadow on a plane perpendicular to it or on a cylindrical surface co-axial with it.

The gnomon of type-1 above being simplest, is quite popular for several kinds of activities at school level, for example ;

1. Study of length of shadow with position of sun going up in the sky (for primary classes). Altitude of sun can be found at a particular date and time (for secondary classes), as shown in fig.1.
2. Finding true north direction, which is the bisector of equal shadows in forenoon and afternoon.
3. Measuring local time (fig.2) from a few hours before noon to a few hours after noon time.
4. Finding altitude of sun at noon and studying variation in it on different dates. If latitude is known, then declination of sun at noon on that date can be found out. If declination of sun is known from the ephemeris (or 0°, or 23.5° or -23.5° on that date) then latitude can be found out (fig.3).
5. Finding altitude of sun at noon on same date simultaneously at two places which are at least 300 km apart in North-South direction, thus finding radius of the earth (fig.4).

The need of precision in the Project : In October 1993, a group of students from a school in Delhi was working on their project with the author. They wanted to find radius of earth by gnomon. But their difficulty was that collaboration 300 km away could not be sought, though simultaneous measurement at two places 50 km apart within Delhi was considered possible.

In traditional use of gnomon we measure length of the shadow assuming sun to be a point source of light, casting a shadow with sharp boundaries (fig.5). But, in reality the shadow does not have sharp boundaries. It has a dark umbra and a penum-

bra with various shades of light (gif.6). Thus the length of shadow can not be accurately measured. Because the sun has an angular diameter of 0.5 degree, the measured altitude has an error of about 0.25 degree.

The Innovation to achieve precision : One of the students pointed out that we are interested in the shadow of the tip of the gnomon. A sharp pointed and casts a blurred penumbra. But if with a spherical source of light like the Sun, we have a spherical object casting the shadow, centre of that shadow can be found by judgement much more accurately. So a small ball was placed at the top of the gnomon (fig.7). The ball is of such a diameter that its umbra is quite small and thus centre of elliptical shadow on the horizontal plane can be judged easily and accurately.

Construction of the improved gnomon : A tripod with a glass base was constructed. The glass plate was chosen to be plane of good quality by observing the reflected image of a distant object in it. At the top of the tripod a vertical sewing needle was fixed with its pointed end upwards. On this pointed end a small ball made of dough (which is used for making chapaties) was fixed (fig.8).

From the eye of the needle a plumb line was suspended. A graph paper was pasted on the base plate of glass. Care was taken to use both ends of the thread passing through eye of the needle for suspending the plumb line. The symmetry thus obtained in the shape of hanging thread makes the plumb line practically vertical, in spite of some stiffness of thread. The bob of the plumb line was also improvised by tying three equal rods on a sewing needle 7.5 cm long, with 1 cm of pointed end of this needle coming out of the rods to function as a pointer to read the position of the plumb line on the graph paper. Position of tip of the plumb line, T, when this gnomon stands on an accurately horizontal plane is found as follows.

The gnomon is first placed on a plane glass surface, which may not be horizontal. Then coordinates of the position, T2, of the tip of the plumb line are read on the graph paper (fig.9a). Next, the gnomon is rotated through 180 degree and coordinates of the new position, T2, of the tip of the plumb line are read. Mid-point of the line segment joining T1 and T2 is the position of the tip of the plumb line for an accurately horizontal plane. Now, the glass sheet on which the gnomon stands can be adjusted, to bring the tip of the plumb line at T, thus making it perfectly horizontal.

The students then took up the more comfortable project to find the declination of sun each day for two weeks by measuring meridian altitude of sun at one place only. Accurate latitude of that place was found from a map of Survey of India. Two slightly cloudy days being lost, results for 12 days were obtained. On comparison with data given in Indian Ephemeris, large systematic deviation was observed. However, when declination of sun for the nojon time at Delhi on each day was referred from Ephemeris, the agreement was good. Mean error of results was 0.05 degree (that is, 3 arc minutes), though on some days, the error was upto 0.12 degree.

A message of National importance : The author wants to communicate a message through this examples of innovation by school students. Whereas our children should share the pride for Heritage of Ancient Indian Astronomy, we must not stop there. We must, at the same time promote their creativity. Practical work and project work in sci-

ence, which should promote one's creative ability and is a part of curriculum, needs to be taken up honestly in schools and colleges. The most creative age in the development of person is from 15 years to 35 years. There was a time when individual research work could fetch one a Nobel Prize and in most cases this prize in physics was won by a young person below 35 years of age or so. Even the big projects which fetch a Nobel Prize to elderly people now-a-days, cannot succeed if we do not promote creativity of the young science students in schools and colleges. In the Indian context, unless we genuinely promote creativity of young science students in their formative years, we are not going to be able to face international competition which is now inevitable.

Acknowledgements : Thanks are due to Gaurav Bansal, Bharat Bhushan, Nitin Jain and Sandeep Juneja, the students of C.R.P.F. Public School, Sector-14, Rohini, Delhi-110042, during the session 1993-94, for their sincere and intelligent project work, which led to development of the improved gnomon.

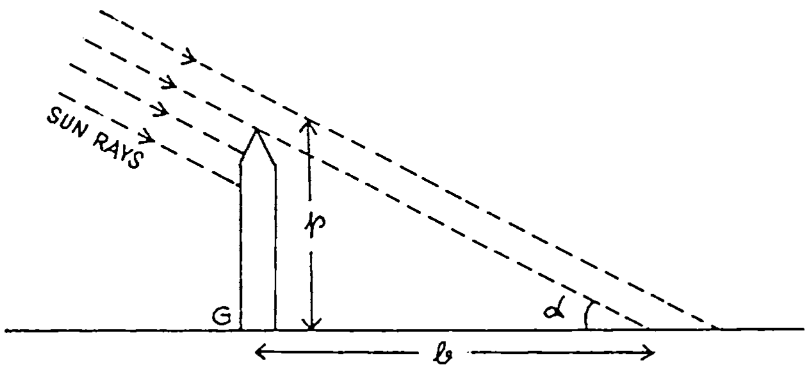


Fig.1 : Altitude $\alpha = \tan^{-1}\frac{p}{l}$

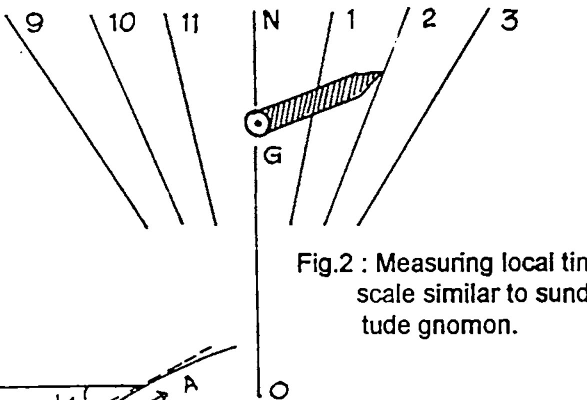


Fig.2 : Measuring local time with OG = cot scale similar to sundial is made. is latitude gnomon.

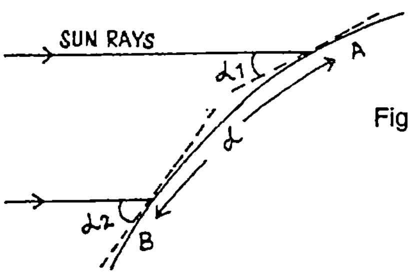


Fig.3 : Measuring radius of EArth $\frac{d}{r} = (\alpha_2-\alpha_1)/57.3$

$r = d \times 57.3/(\alpha_2-\alpha_1)$

α_1 & α_2 are meridian altitudes of Sun at stations A and B respectively

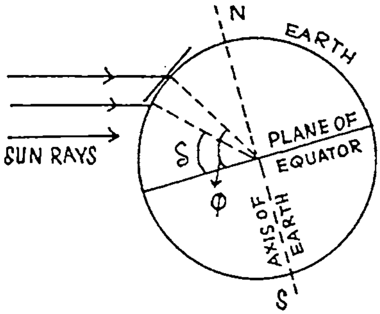


Fig.4 : Measuring , the declinatijon of Sun. In this sectional diagram of Earth, ϕ = latitude

$\therefore 90^\circ - \alpha = \phi - \delta$

$\Rightarrow \delta = \phi + \alpha - 90^\circ$

α = meridian altitude of Sun

Fig.5 : In gnomon experiments shadow is usually treated as sharp, as if Sun is a point source of light

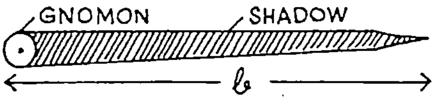
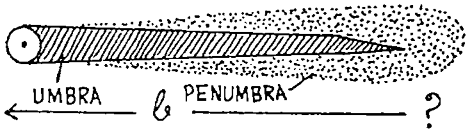


Fig.6 : Sun being an extended source of angular diameter 0 .5°, there is a penumlra in the shadow of gnomon. This causes uncertainty in, the length of shadow and thus an uncertainty of about 0°.5 in mea sured value of, the altitude of sun.



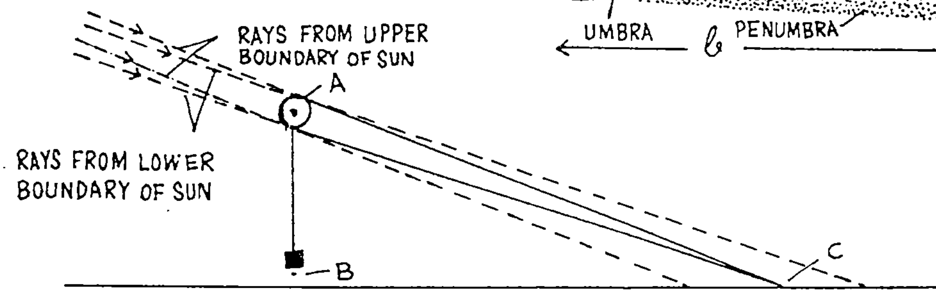
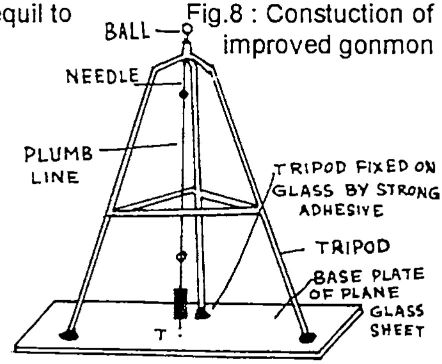


Fig.7 : A is the centre of tiny ball at upper end of gnomon. B is tip of plumb line vertically below A. C is centre of the shadow of ball on horizontal plane. Altitude of centre of Sun's disc is equil to $\tan^{-1}$ (AB/BC)

Fig.8 : Constuction of improved gonmon



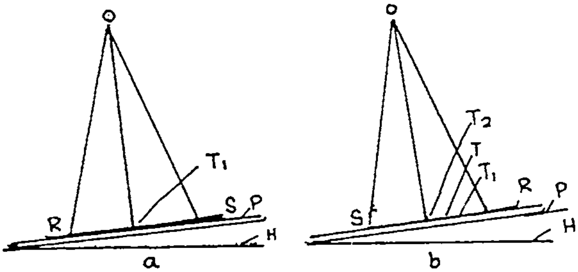


Fig.9 : Position T of the tip of plumb line for accurately horizontal plane can be found on any plane surface P which may not be parallel to horizontal plane H.

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MY TELESCOPES

Manmohan Choudhury

Telescope mania had gripped me when I was about ten years old, back in 1924 or 1925. Our neighbour had a set of the Book of Knowledge of which I had become an avid and regular reader. As I didnot have to go to school, my father having noncooperated, I had enough time to myself and a chance to savour the wide world opened up by the set of children's books. In it I came across instructions on building a telescope, a 2 inch one. In the book it was very simple : you get hold of a 2 inch objective lens with a focal length of 24 inches and a smaller one for the eyepiece, roll a cardboard tube and fix the lense into it and the telescope is ready. But on ground it was not so easy. Cuttack was then a small town with a population of about 50,000 and there of course were no science shops. One day I set out with a family friend, who later became a leader in the freedom movement, in search of the lenses. There was only one optical shop in the town and of course they had only lenses for specs.

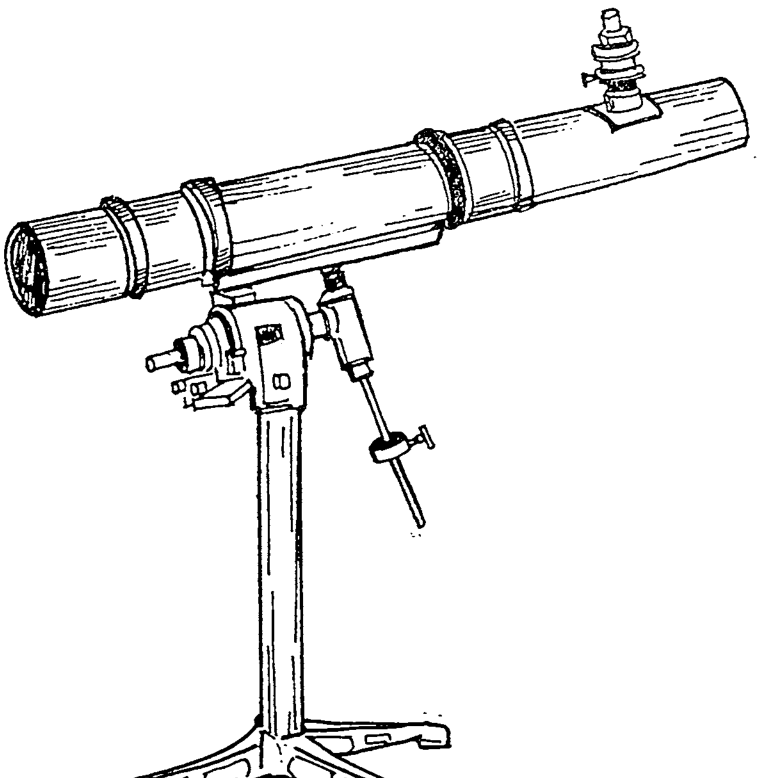
Later on I got hold of a broken magnifying glass and a smaller lens out of some other gadget and built a telescope with a cardboard tube out of which I and my friends had hours of fun watching terrestrial objects. The fascination of the skies had not yet hit me. Of course when I was a child my father used to show me the constellations when we would be resting on our rooftop on summer nights before going to sleep. I had vague memories of them and their names. Later on in the 30s I got hold of books on astronomy and popular tracts by Jeans, Eddington and other scientists as by then I had begun to wonder about the nature of the universe we were living in. These books whetted my curiosity about the wonders of the sky, but by then the cardboard telescope had been lost. The only wonderful object I could spot with my naked eyes was the galaxy in Andromeda.

Thereafter the yearning for a telescope lay dormant for fifty years or so till I visited the USA in 1984 where the mania re-surfaced. I caught hold of a book on telescope making and then acquired a 6 inch mirror, a diagonal and an eye-piece. I built the telescope when I came back to Cuttack with the help of local artisans. They and I had to overcome innumerable snags that faced us as we went ahead with our own plan adapted to the materials available locally. It was a great day when the scope was ready and I could see the mountains on the moon, ,the Orion nebula, the Andromeda galaxy, the rings of Saturn, the four moons and the dark bands of Jupiter and the crescent of Venus. Then I started hunting for the spectacular galaxies, nebulaes, star clusters and other wonders of the sky.

As I needed a bigger telescope to be able to see the outer planets, Uranus, Neptune and Pluto, I decided to build a 12.5 inch telescope and have built it with the opticals procured from abroad. This was a more demanding task than I had expected it to be, the snags multiplying in ratio to the square of the diameter of the mirror, but the successful completion of the project has been greatly satisfying.

The Bhagavat Gita describes how Shrikrishna revealed to Arjuna his cosmic self - Vishwa Rupa - and gave him supernal or transcendental vision so that he could perceive it. Today the microscope and the telescope are the two instruments that provide us with glimpses of the cosmic self, of the grandeur, beauty and mysteries of the microcosm and the macrocosm. When I look ,through the telescope at some distant galaxy, may be ten million light years away and of which light takes a hundred thousand years to reach from one end to the other, I have visiion that places our terrestrial existence in proper perspective and makes worries, tensions, and fears melt away. It gives me a kind of spiritual experience that lifts me out of mundane life so that I can pursue my other activities with renewed zest. I realise why poet Rabindranath Tagore sang : The sky is full of suns and stars and life fills the earth. It is in the midst of this that I have had my birth. And so songs spring from my wondering heart.

Bakhara Bag
Cuttack-2



RELEVANCE OF PLANETARIUM IN AMATEUR ASTRONOMY

Jayadev Kar

The twenty first century is just around the corner. With the full scale space age right before our eyes, scientific education is about to undergo a major transition. What we need is to develop science through amateurs. At present Amateur Astronomy is one of the most interesting and fascinating areas of science which attracts the imagination of child, young and old alike. From time immemorial, amateur astronomers have been inquisitive to watch the starry sky. He has wondered what those tiny specks of light could be ? Are there human beings elsewhere in the universe ? What is the truth behind creation of the universe ? To some of these difficult problems amateurs have obtained answers through dedicated and ceaseless sky observation. Most of the comets, stars, contellations etc., have been identified / recognised by amateur astronomers. Fictions of the past have come to be reality. Besides sky observation amateurs have played an important role in popularising science, removing the blind believes from the common mass, establishing the truths of day to day life.

Planetaria throughtout the world have been a useful tool for the amateurs. It can create sky pattern and celestial phenomena according to one's choice through opto-electronic aids. The planetarium projector is the central equipment for creation of such situations and sights in addition to special effect projectors.

In India we generally come across three types of planetarium system, named as (a) Carl Zeiss Jena from Germany (b) Spitz from U.S.A. (c) Goto Optical Mfg. Co. from Japan. Other leading planetarium systems are found from Minolta and Digistar (not in India). Out of the planetaria available in India, some are purely mannual and some are totally automatic with mannual facility. At present at least thirty planetaria are working successfully through out India, out of which two are from Spitz, twenty (approx) from Carl Zeiss and eight (approx) from Goto Optical Mfg. Co.

The amateur astronomers are utilising the planetaria in the following ways.

1) Education in day to day life

2) Creation of celestial phenomena in time and space

3) Development of scientific temper through entertainment

4) Use of planetarium equipment in teaching astronomy

5) Training in navigation through sky maps

6) Travel to space

7) Extensive programmes under workshop on astronomy series

Generally it is not possible to see the celestial bodies in the day time. But one can take the help of a planetarium equipment to see the stars, planets etc., not only in day time, but also one can have the sky pattern of any desired date, past or future, before his eyes by the ncontrol of the machine on the roof of the hallow hemisphere. The rare events like the total solar eclipse and its different features, total lunar eclipse, transit of the mercury over the sun, crash of Shoemaker-Levy 9 comet on Jupiter, etc., can be seen at any time in a planetarium show with the help of sophisticated opto-electronic equipments.

Launching of a satellite, landing of a spacecraft on a planet or its satellite are some of the attractive events shown at a planetarium. The feeling of rotation, revolution, precision-motion of the heavenly bodies can be understood with the help of the main projector of the planetarium equipment. The B-type projector, Space-ship projector, Image rotating projector, Zoom slide projector, Multi-slide projector etc., perform their unique operations to make a planetarium programme, attractive, enjoyable, educative.

Four rotational axes, namely diurnal, latitude, azimuth and precession are automatically controlled by a computerised system to rotate the planetarium about a hypothetical axis. All forms of movements in space can be reproduced. With the advent of newly developed shutters it has been possible to create the sensation of flying in space while the viewer is actually stationary on his seat. Domes in some planetaria can even tilt. Effects of above shutters under a tilted dome creates arrie experience. Hydraulic system with the help of astrovision gives an astounding feeling of the space in a hemispherical auditorium. The planetarium can be used as class room to demonstrate the nature and motion of celestial bodies and the related properties.

Projectors with large field of view, randomly changing line of sight for each axis, multi image facility bring three dimensional effect inside the auditorium. The blue of the sky, red of the rocket flames and mystrious purple of the deep space can be shown on a single dome.

What we need is the learning not through abstraction and imagination but one which allows the kind of first hand knowledge that results from observation and experience. Starting from planetarium show to popularisation of science, space technology to research, indentification of celestial bodies to navigation planetarium helps us a lot.

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SCHOOL SCIENCE AND AMATEUR ASTRONOMY

B. K. Pattanayak

Science is a way to look around. All animals, who have eyes, can look at things. We, human beings, cannot know what goes on inside the minds of other animals, when they look at things. But from their visible actions we are able to make out something. When a dog or crow sees a thing lying somewhere, it comes near that; opens it in own way and tries to find if there is anything edible. But human's way of looking at things is quite exhaustive. We try to find out in what way the thing can be applicable to our unending needs. Food, clothes, shelter etc. are small parts of our needs. The major need lies in his unending curiosity and apetite for knowledge and discovery.

The search for these discoveries starts with its natural curiosity; grows with interest; sharpens with observation and imagination; gets refined with experiments and logical thinking; leads to hypotheses ; proofs and universal apoplication open up a truth, or law. This noble path of science has guided the human civilizations in all ages to explore the beauty and splendour of the Universe.

All humans are naturaly scientists with vast curiosity and ability to discover things. Children are superb in these abilities for their tremendous curiosity, enthusiasm, energy and creativity. They can never sit idle. They always go on trying new things with novel ideas and imaginations which the elders can never be able match. School science aims at organising and sharpening these scientific skills.

But science teaching methodology in our schools is quite wrong and rather directionless and has proved to be quite destructive to the little scientists. A large gap remains between what is said (theory) and what is done (practice) in the field.

1. Science education should always start with nearby surroundings. But neither text books nor teaching touches upon the local trees, soil, water, mountains, animals, sky or people. Rather it highlights alien descriptions beyond the child's imagination and the miracles of science, like technological development. This makes the child feel that science means something beyond their imagination; very complicated, full of theories to be byhearted and has no relationship with day to day life.

2. Children should test and realise the different aspects of science. Everybody uses the terms like "learning by doing", "low cost" "no cost experiments", "hands on activities" etc.

3. Teacher should be friend, pholosopher and guide to the children.

4. Children should be encouraged to exchange their ideas, queries and thoughts.

5. Scientific spirit should be inculcated in the students.

The conventional method of teaching in nour schools simply kills the natural creative and exploring abilities of children and makes them inactive and callous to all challenges in life. Their science ends with the examinations and finds no use in daily life. The whole of India suffers of this unscientific and wrong teaching process.

In this context, amateur astronomers have a vital role to play. Amateur astronomy is not a mere hobby for them. If is part of their nature and life. This natural approach is very much needed in the teachers. A teacher who is watching the sky, developing a garden, innovating models or designing crafts or possessing other creative abilities like playing, singing, dancing, imparts tremendous impact on children. Children run after him blindly and emotionally. They follow his/her skills with natural love and appreciation.

Astronomy is the oldest and most exciting of all sciences. Everybody gets carried away by the beauty and splendour of the sky. The experiences cannot be narrated with mere words. Dry facts and figures on the solar system, stars and galaxies can never tempt a child to come out and peep into the sky. Students have to come out of their home and books. They should know to identify the beautiful shapes in the sky. Taking things as they are in our educational system lovers of sky have to play a vital role here. They are the only persons who can divert the creative minds from the dry arena of school curriculum to an open laboratory of the free sky.

Growth of amateur astronomers' groups is a good sign in this context. The attraction towards this topic is basically due to the great mystry of the sky. One cannot but just appreciate it. Anybody in the society - poor or rich, young or old, lettered or unlettered even can enjoy it village or metropolitan. One can go for higher studies as a professional astronomer and the whole life would seem to pass like a meteorite in the vast universe.

The sky is patterns like caste, creed, languages, colours, countries, riches, power etc. Hence a common complaints of a village school teacher about lack of instruments, lack of facilities etc., vanishes automatically. The village sky looks more attractive than the light affected town/city sky.

All amateur astronomy activities can be well organised if they start with the school. At primary level, science or environment education touches upon sky and stars. Sky watching programmes at this level would have remarkable impact on children. The discussions related to sun, moon, planets, stars etc. along with regular observations can sensitize the children to think and realise the beauty of celestial phenomena. There can be activity oriented projects relating to the celestial phenomena like rising and setting, positions, brightness, sizes, colours, and magnitudes of stars and planets, eclipses, phases of moon, etc. The initial observations related activities can be followed up by activities relating to instrumentation, telescope making, model making, drawing sky maps/ charts and similar activities. Along with these there can be intensive study on the subject through libraries, seminars, and exposure to higher facilities. These programmes are a very rough sketch of some amateur astronomy activities. But the main aim behind all these activities is to create interest in the children. Once that is created, opportunities for higher studies or deeper activities are ample. Theoretical or practical research work on the topic can be a life-long process. But without interest, there can be no fun or continuation at all. What can happen, due to lack of interest and appreciation, is clearly visible in the present school and society.

Amateurs, although few in their number, yet have shown the altematives. They themselves have appreciated the beauty and splendour of the sky not merely through school teaching, but through their own curiosity and interest. The more they enjoy it and the more they get involved in newer and sensitizing activities, the more they will vibrate the society and people's interest. Teachers, supposed to be guides of the society are to be touched and motivated through these innovative activities. When a teacher tums out to be an interested amateur astronomer, then we would not have to bother about the mechanical facts of the book, or rigid curriculum or a directionless syllabus. The sky would tum out to be a real story book with endless fun and challenges. But to taste it the average human senses and systems are yet to be opened up. Once the parents and teachers are sensitized, today (in us) and tomorrow (in children) and the incubator (the school), all will fluorish like the jewels in the sky.

The amateur astronomers will have to play this link role. They would have to look at the social problems and the possibilities. The challenge is that can they rise to the occasion and open up all eyes to the beauty and splendour of the sky ? It is on and possible.

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Bhubaneswar

ASTRONOMICAL EVENTS

HUBBLE OBSERVATIONS SHED NEW LIGHT ON JUPITER'S COLLISION

R. Jain

In the weeks following comet P/Shoemaker-Levy 9's spectacular July collision with Jupiter, a team of Hubble Space Telescope astronomers has pored over imaging and spectroscopic data gleaned during the interplanetary bombardment. Their initial findings, combined with results from other space-borne and ground-based telescopes, shed new light on Jupiter's atmospheric winds, it's immense magnetic field, the mysterious dark debris from the impacts, and the composition of the doomed comet itself.

The Jupiter :

Some 4.6 billion years ago, Jupiter began to form from collisions of small icy bodies condensed from the parent solar nebula. These icy bodies collided and agglomerated into a protoplanet. The energy from these collisions was converted to heat and stored in the planet. As Jupiter grew, it trapped a huge hydrogen-rich atmosphere from the nebula, which insulated the core so that it could retain some of its primordial heat.

Over 4 billion years later, Jupiter is still cooling. It radiates about 1.67 times more heat than it absorbs from sunlight. This extra energy is transported upward by convection from the hotter core. This energy, combined with the fact that the giant planet rotates in less than 10 hours, generates strong east-west winds. These winds are deeply rooted within the planet and involve the motions of huge masses of gas.

Jupiter has 16 moons, a equatorial ring of debris, and a magnetic field at the cloud layer that is 25 times stronger than Earth's. Further, Jupiter's magnetosphere is so vast, if visible to the naked eye, it would be about the size of the full moon. Although, Jupiter dominates the planets in our system, it is 1,000 times less massive than the Sun and, even though its volume is more than 1,300 times that of Earth, it is only 318 times more massive. This is because, like the Sun, Jupiter is composed mainly of the lightest elements - hydrogen and helium.

Jupiter orbits the Sun every 11.86 years in an orbit that takes it 5.2 times farther from the Sun than Earth. At this distance, Jupiter receives only 4 percent of the solar heat per unit area that Earth does. At the visible cloud tops, its temperature is only -130° C. Above the clouds, ultraviolet sunlight has interacted with trace ammonia and methane molecules to form yellow-orange smog in the hydrogen-helium rich atmosphere. Less than 100 meters below the opaque ammonia cloud deck that we can see from Earth and spacecraft, pressures are 6-10 times that at sea level on Earth.

There, oxygen and hydrogen combine to form a hidden cloud of water ice. Below the water clouds, the atmosphere becomes denser and denser until finally its gases take on characteristics similar to those of metallic substances. Still, there is no level where there is an abrupt change of state from gas to a liquid or solid; therefore, unlike on Earth, this planet has no oceans or continents to disrupt the atmospheric motion. Thus, when convective bubbles from the interior generate long-lived storms, they are not destroyed like earthly hurricanes are when they encroach on land.

The largest of the long-lived storm systems is the Great Red Spot at 20 degrees South latitude. This storm has raged on at least since 1610, when Galileo first observed it. In length it is more than twice the diameter of Earth. The white Ovals, smaller storms that formed in the late 1930s, are over 9,000 Km in length. They speed up and slow down as they drift eastward near 30 degrees South latitude. Other well-known features, such as brown spots and equatorial plumes, were studied in detail by the NASA Voyager scientists after the spacecraft encounters in 1979. They also studied convective storms, comparative in size to Earth's radius, which dissipated within days.

Jupiter's clouds are strung out in colourful band structure because of alternating east - west jets. Ralative to the rotation of the core, near 6 degrees South the wind blows eastward at 500 Km per hour, at 17.5 degrees South, the wind is 240 Km per hour westward, and at 24.5 degrees it is eastward at 200 Km per hour. The Red Spot is forced into a counterclockwise rotation between the 17.5 degrees westward flow and 24.5 degrees eastward wind. This allows slow upward flow in the interior of the Red Spot, helping to sustain this long-lived storm.

Although we have studied other storms on Jupiter, we do not know at what depth the disturbances were generated. Nor do we know how much energy was inserted into the lower atmosphere to create the upwellings that we observed. Shown in Figure 1 is picture of Jupiter taken by the nHubble Space Telescope before Comet Collision.

The Comet Shoemaker-Levy 9 :

Comet Shoemaker-Levy 9 was one of a large population of icy and rocky bodies that inhabit our nsolar system. There may be billions of them orbiting the Sun far beyond the realm of Pluto, in a spherical conglomeration called the Oort Cloud. There is probably another grouping in the Kuiper Belt, a flat disk of comets just outside the orbit of Pluto.

Comet Shoemaker-Levy 9 is the nonly none that we have ever observed actually in orbit around a planet, although we have discovered several other comets shortly after they were ejected from orbits around Jupiter. We now think that it may be fairly common for Jupiter to capture a comet temporarily. The comet will survive its orbit only a few years to a few decades before it is ejected or, less frequently, crashes into the planet. An image of Shoemaker-Levy 9 comet obtained on 1 July, 1993 by HST is shown in Figure 2.

On JUly 8, 1992, Comet Shoemaker-Levy 9 passed too close to Jupiter and tidal forces raised by the planet's gravity tore it apart. We frequently observe comets breaking into pieces, often when they are close to the Sun or Jupiter, but sometimes the breaking also happens when the comets are not near any other large body. The schematic of Comet SL-9 orbit around Jupiter is shown on Figure 3.

THE LAST DAYS OF THE COMET :

Before the comet impact, there was a great deal of speculation and prediction about whether the 21 nuclei would survive before reaching Jupiter, or were so

fragile that gravitational forces would pull them apart into thousands of smaller fragments. Hubble Space Telescope (HST) helped to solve this question by watching the nuclei until about 10 hours before impact. HST's high resolution images show that the nuclei, the largest of which were probably a few kilometers across, did not breakup catastrophically before plunging into Jupiter's atmosphere. This reinforces the notion that the comet's atmospheric explosions were produced by solid, massive impacting bodies. The development of "the Gang of four nuclei" of comet is projected in Figure 4.

HST's high resolution also showed that the nuclei were releasing dust all along the path toward Jupiter, as would be expected from a comet. This was evident in the persistence of spherical clouds of dust surrounding each nucleus throughout most of the comet's journey. About a week before impact, these dust clouds were stretched out along the path of the Comet's motion by Jupiter's increasingly strong gravity.

PIERCING JUPITER'S MAGNETIC FIELD :

About four days before impact, at a distance of 3.5 million Km from Jupiter, nucleus "G" of Comet Shoemaker-Levy 9 apparently penetrated Jupiter's powerful magnetic field, the magnetosphere. Hubble's Faint Object Spectrograph (FOS) recorded dramatic changes at the magnetosphere crossing that provided a rare opportunity to gather more clues on the comet's true composition. During a two minute period on July 14, HST detected strong emission from ionized magnesium (Mg II), an important component of both comet dust and asteroids. However, if the nuclei were ice - laden as expected of a comet nucleus - astronomers expected to detect the hydroxyl radical (OH). The HST did not see OH, casting some doubt on the cometary nature of Shoemaker-Levy 9. Eighteen minutes after comet Shoemaker-Levy 9 displayed the flare-up in Mg II emissions, there was also a dramatic change in the light reflected from the dust particles in the comet. In Figure 5, the G impact plumes that extended more than 2000 Km above Jupiter's normal cloud surface are shown.

NEW AURORAL ACTIVITY :

The HST detected unusual auroral activity in Jupiter's northern hemisphere just after the impact of the comet's "K" fragment. This impact completely disrupted the radiation belts which have been stable over the last 20 years of radio observations.

Aurorae, glowing gases that create the northern and southern lights, are common on Jupiter because energetic charged particles needed to excite the gases are always trapped in the planets' magnetosphere. However, this new feature seen by Hubble was unusual because it was temporarily as bright or brighter than the normal aurora, short-lived, and outside the area where Jovian aurorae are normally found. Astronomers believe that the K impact created an electromagnetic disturbance that travelled along magnetic field lines into the radiation belts. This scattered charged particles, which normally exist in the radiation belts, into Jupiter's upper atmosphere. In Figure 6, UV image of Jupiter is shown to project the Aurorae and superimposed Magnetic Field lines.

X-ray images taken with the ROSAT satellite further bolster the link to the K impact. They reveal unexpectedly bright X-ray emission, mainly field lines con-

nected to the impact site, that was brightest near the time of the K impact, and then faded.

SWEPT ACROSS JUPITER :

Shown in Figure 7, is an UV image of Bruised Jupiter obtained from HST on 21 July 1994. Observations made with HST's Wide Field Planetary Camera-2, a week and a month after impact, have been used to make global maps of Jupiter for tracking changes in the dark debris caught in the high speed winds at Jupiter's cloudtops. This debris is a natural tracer of wind patterns and allows astronomers a better understanding of the physics of the Jovian atmosphere. The high speed easterly and westerly jets have turned the dark "blobs" originally at the impact sites into striking "curly-cue" features. Although individual impact sites are still visible a month later despite the shearing, the fading of Jupiter's scars has been substantial and it now appears that Jupiter will not suffer any permanent damage from the explosions.

Hubble's ultraviolet observations show the motion of very fine impact debris particles now suspended high in Jupiter's atmosphere (before eventually diffusing down to lower altitudes). This provides the first information ever obtained about Jupiter's high altitude wind patterns. Hubble gives astronomers a "three dimensional" perspective showing the wind patterns at high altitudes and how they differ from those at the visible cloud-top level. At lower altitudes, the impact debris follows east-west winds driven by sunlight and Jupiter's own internal heat. By contrast, winds in the high Jovian stratosphere move primarily from the poles toward the equator because they are driven mainly by auroral heating from high energy particles.

WHAT IS THAT DARK STUFF MADE OF ?

The HST Faint Object Spectrograph (FOS) detected many gaseous absorptions associated with the impact sites and followed their evolution over the next month. Most surprising were the strong signatures from sulfur-bearing compounds like diatomic sulfur (S_2), carbon disulfide (CS_2), and hydrogen sulfide (H_2S). Ammonia (NH_3) absorption was also detected. The S_2 absorptions seemed to fade on timescales of a few days, while the NH_3 absorptions at first got stronger with time, and finally started fading after about one month. During observations near the limb of Jupiter, the FOS detected emissions from silicon, magnesium, and iron that could only have originated from the impacting bodies, since Jupiter itself normally does not have detectible amounts of these elements. Shown in Figure 8 is the spectra of energy of G impact site as compared to "normal" spectrum before the impact at the same location.

WAS P/SHOEMAKER-LEVY 9 - A COMET OR AN ASTEROID ?

At present, observations seem to slightly favour a cometary origin, though an asteroidal origin cannot yet be ruled out. The answer is not easy because comets and asteroids have so much in common : they are small bodies; they are primordial, forming 4.6 billion years ago alongwith the planets and their satellite; either type of object can be expected to be found at Jupiter;s distance. The key difference is that comets are largely icy while the asteroids are virtually devoid of ice because they formed too close to the Sun. The attached table summarizes the observational results that shed light on this question.

Acknowledgements

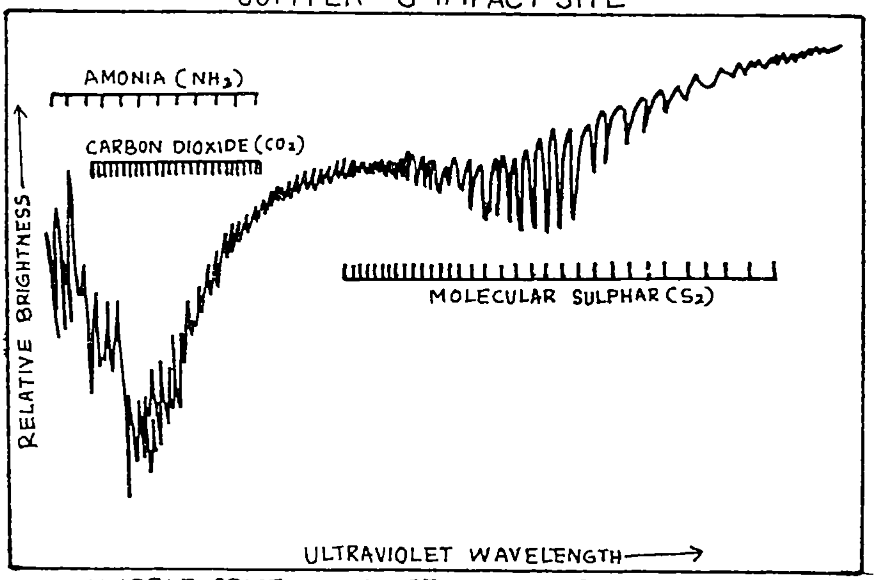
The author is highly grateful to Space Telescope Science Institute and NASA to provide the latest informations with Hubble and other space - borne observations to enable him to write this article.

P/Shoemaker-Levy 9 : Comet or Asteroid ?

Property	Comet	Asteroid
Orbit	Yes	Yes
Low Strength	Yes	Possibly
Coma & Tail	Yes	Yes
Spherical Coma	Yes	Probably not
Mg II, no OH	Possibly	Yes
Water in plumes	Yes	Yes

Conslusion : Evidence slightly favours cometary origin, but asteroidal origin is not ruled out.

JUPITER · G IMPACT SITE



HUBBLE SPACE TELESCOPE • FAINT OBJECT SPECTROGRAPH

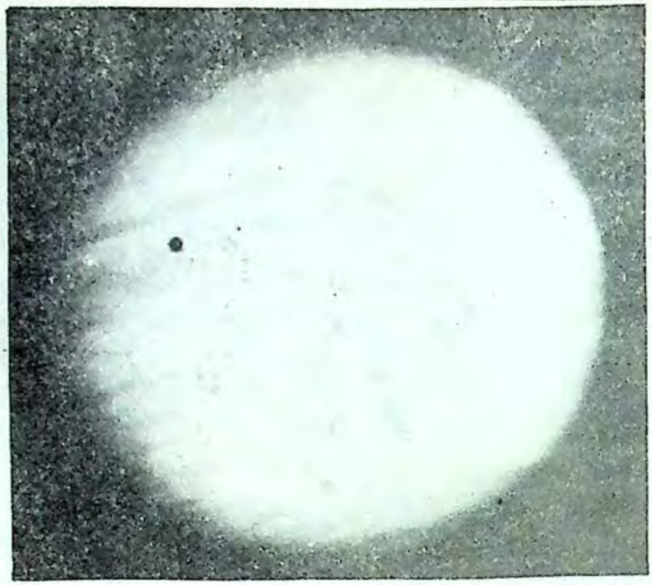


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Fig. 1

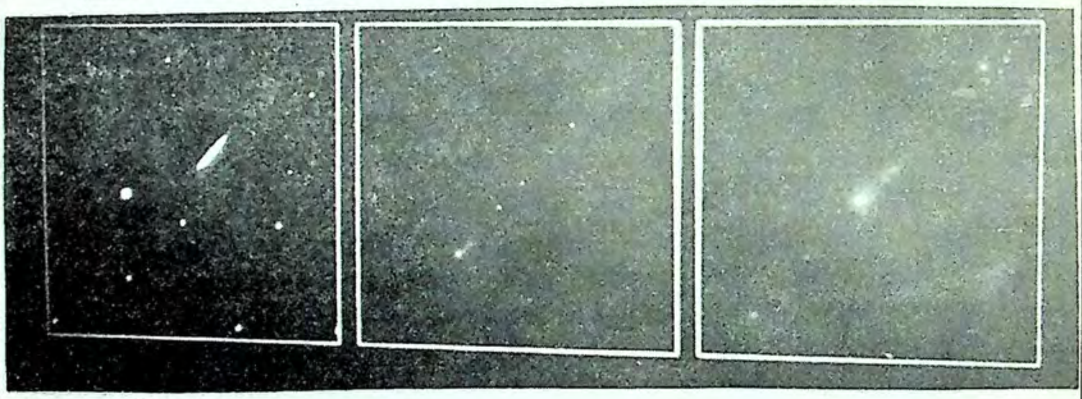


Fig. 2

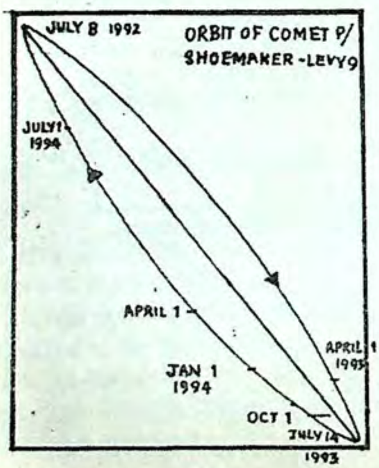


Fig. 3

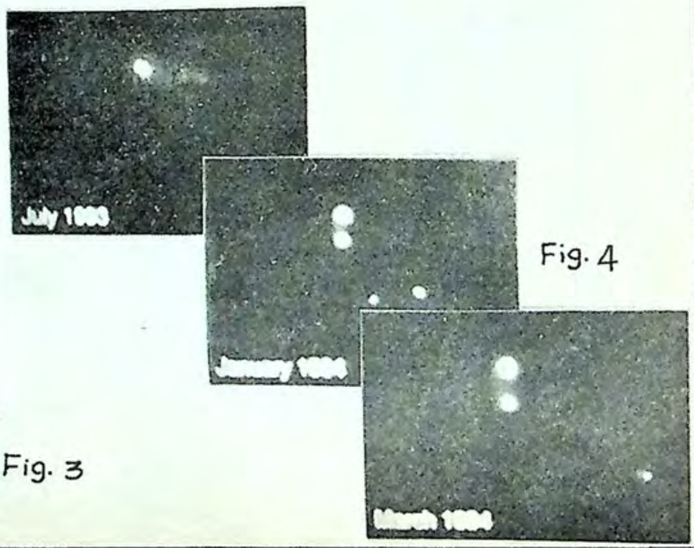


Fig. 4

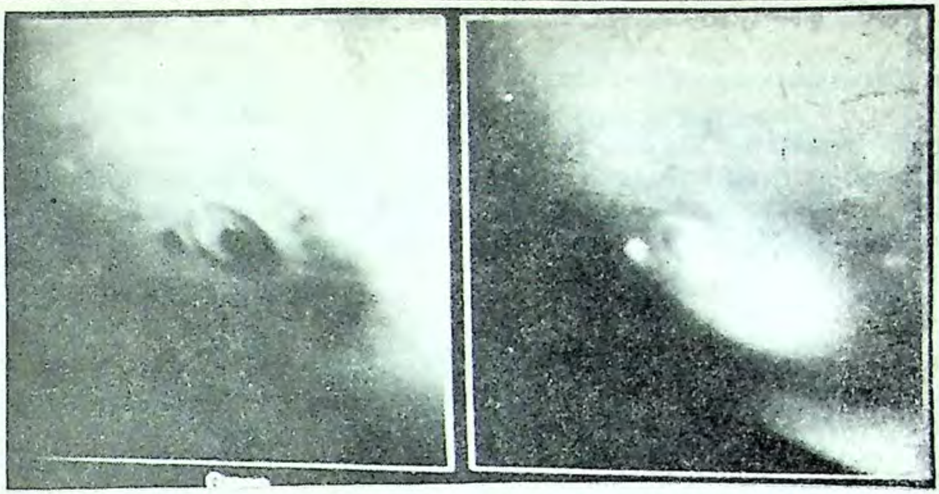


Fig. 5-a

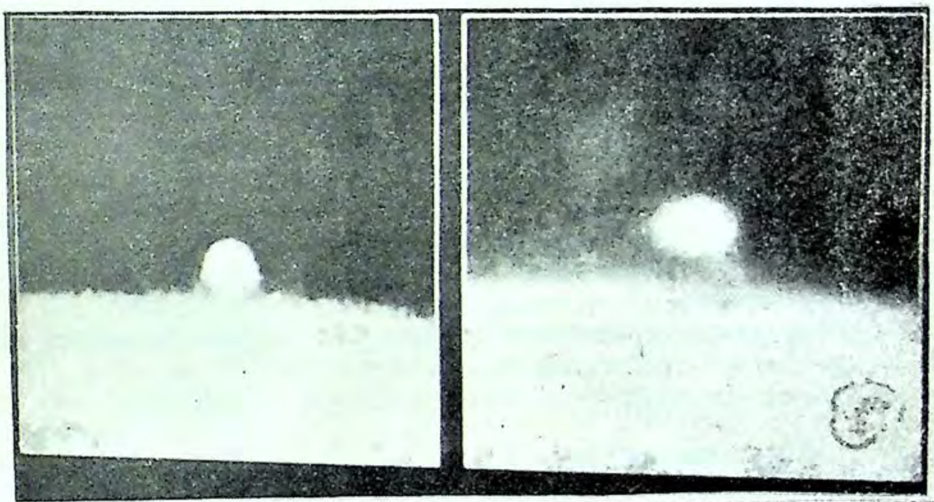


Fig. 5-b

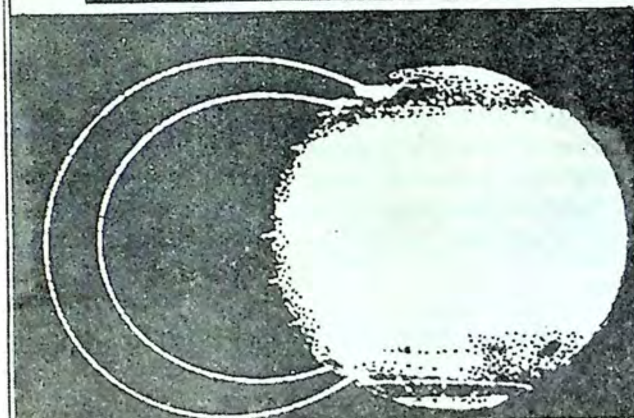


Fig. 6

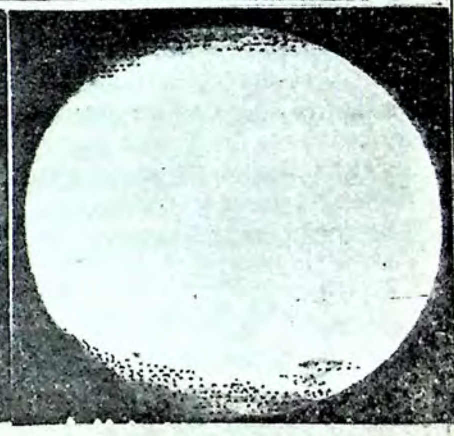


Fig. 7

FIGURE CAPTIONS

Figure 1 : This image of Jupiter was taken on 18 May 1994 before the Comet Collision by the wide field and planetary camera-2 in wide-field mode aboard the Hubble Space Telescope. At that time Jupiter was 670 million Km from the Earth. The dark spot on Jupiter's disk is the shadow of Io, innermost of Jupiter's four Galilean satellites. (Photo Credit : STSI & NASA)

Figure 2 : (Left) An image of P/Shoemaker-Levy 9 obtained on 30 March 1993 - one week after the comet's discovery - with the Spacewatch Camera of the University of Arizona.
(Centre) First HST image of P/S-L9 with WF/PC1 on 1 July 1993 ; two weeks before the comet's final apojove.
(Right) An enlargement of the HST image near the brightest region which include fragments R, Q, and P (from left to right). Over the course of time, this portion of the comet train - notably fragments Q and P - temporally evolved into the "Gang of Four". (Photo Credit : University of Arizona and STSI & NASA)

Figure 3 : Periodic Comet Shoemaker-Levy 9 (P/S-L9) sealed its fate on 8 July 1992 when it passed 21,000 Km from Jupiter. The nucleus was tidally disrupted into a score of cometary fragments.
This diagram shows the extreme ellipticity of the fragments' orbit.)Photo Credit: STSI & NASA)

Figure 4 : (Upper Left) The "Centre of Light" or brightest region of P/S-L9 observed on 1 JUly 1993 (prior to the HST servicing mission). From left to right, the fragments are R, P, and Q. The separation of P and Q is 0.3 arc-sec; ground-based telescopes could not resolve this fragment pair.
(Centre) This is the first HST observations of P/S-L9 following the servicing mission. This image of "The Gang of Four" was taken on 24 January 1994. The bright fragments near the top centre are Q1 and Q2, respectively. Below Q2 is P1. To the right of P1 is P2.
(Lower right) Another PC image of the "Gang" obtained on 30 March 1994, shows that the faintest fragment, P1, is now barely discemible. Meanwhile, P2 appears to have fragmented further, creating daughter products P2a and Prb. (Photo Credit : STSI & NASA)

Figure 5 (a) : (Left) The left image was obtained through a green filter (5550 Angstroms) at 1 hour and 45 minutes after the G fragment impacted Jupiter.

(Right) The right image was obtained through the filter sensitive to methane (8890 Ang stroms). The darker expanse around the brighter impact site betrays the presences of methane (CH_4) clouds that absorbs sunlight at this (8890) wavelength. The impact site appears bright due to sunlight reflected off material, probably aerosols, ejected high above the CH_4 cloud layers. (Photo Credit : STSI & NASA)

Figure 5(b) : Two exposures obtained with WFP2 show the G impactor at two times. The G impact plume extended more than 2000 Km above Jupiter's nominal cloud "surface".

Figure 6 : One of the goals of the HST Jupiter campaign was to observe the effects of P/S-L9 (and its attendant dust) must have on the Jovian aurorae. In this image, two magnetic field lines are superimposed into the UV image of Jupiter. Note the aurorae surrounding both the south and north poles of Jupiter.

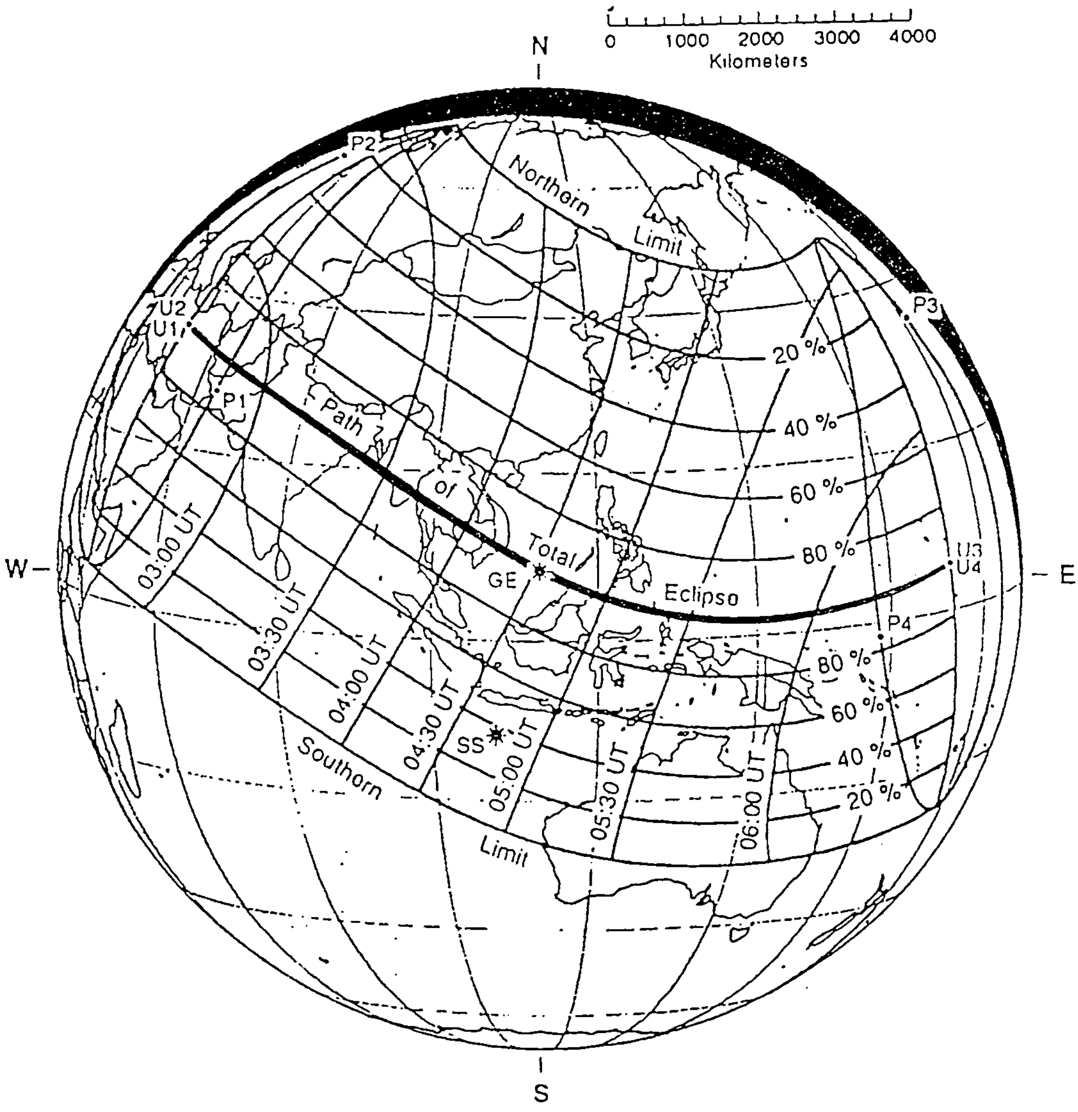
Figure 7 : WF/PC2 obtained the ultraviolet (UV) image of Jupiter on 21 July 1994 about 2.5 hours after R impacted the planet. Jupiter's atmosphere is seen here at 2550 Angstroms. The aerosols, dust particles, etc. spewed upwards from the cometary impacts should act as good "tracers" to better determine the physical characteristics of Jupiter's stratosphere.In this image, several impact features are visible. A large, dark patch from the impact of fragment H is visible rising on the moming (left) side of Jupiter. Proceeding to the right, other dark spots were caused by impacts of fragments Q1, R,D, and G (now one large "splotch"), and L, with L covering the largest area seen thus far. Small dark spots from B, N, and Q2 are visible with careful inspections. The spots are very dark in UV because a large quantity of dust is being deposited in the Jovian stratosphere. The solitary dark spot just above the center of the planet, is Jupiter's moon, Io, (Photo Credit : STSI & NASA)

Figure 8 : The spectrum shown is a ratio of the G impact site a few hours after impact and a "normal" spectrum of the site obtained several days before the impacts began. Dividing an "after" by a "before" spectrum removes the many features normally present in Jupiter's spectrum and in the spectrum of the reflected sunlight. What is left is only what has changed in Jupiter's atmosphere because of the impacts.

Most of the narrow absorption bands seen in the ratio spectrum are from ammonia (NH_3), carbon disulfide (CS_2), and molecular sulfur (S_2). Hydrogen sulfide (H_2S) is evident as a much broader absorption band. Some of the sulfur contained in these molecules could have come from the G fragment itself, but the quantity of S(especially in S_2) is too great for all the S to have come from the impactor, some of the S must have come from Jupiter itself. NH_3 has long been known to exist in Jupiter's atmosphere. However, following the colklisions, NH_3 appears in greater abundance at the impact sites.

THE TOTAL SOLAR ECLIPSE OF 24TH OCTOBER, 1995

Geocentric Conjunction = 04:22:31.1 UT J.D. = 2450014.682304
Greatest Eclipse = 04:32:29.5 UT J.D. = 2450014.689230
Eclipse Magnitude = 1.02134 Gamma = 0.35176
Saros Series = 143 Member = 22 of 72



THE TOTAL SOLAR ECLIPSE OF 24TH OCTOBER, 1995

N. C. Rana

The theme of our calender for this month of February has been chosen to commemorate an extraordinary celestial event that took place exactly fifteen years ago, to be more precise, on February 16. 1980, and to make you aware of its recurrence over the soil of our country on October 24 of this year. Many of you might have the sweet memory of witnessing the event of the Total Solar Eclipse of February 1980. Its track passed over a thin belt of about 130 kilometres wide running from somewhat south of Goa as an entry port to cross over the Indian Terrain through the Sun Temple of Konark on the east before it entered the Bay of Bengal. In fact, that eclipse track originated somewhat west of Africa in the Atlantic ocean and finally ended in China.

The track of the forthcoming Total Solar Eclipse of October 24,1995 will begin with the sunrise at about one hundred kilometres south of Teheran in Iran and sweep over Afghanisthan and Pakistan before it enters somewhere near Alwar in Rajasthan. The Moon's shadow would hardly take about eight minutes from Teheran to reach India at about 8:00 A.M. (IST). Within another 20 minutes it would exit in to the Bay through Diamond Harbour and a few of its neighbouring Deltas.

The measure of the Moon's shadow causing this particular total solar eclipse would hardly be 40 to 50 kilometres wide and 80 to 100 kilometres long. The shadow will naturally appear to be elongated in the east-west direction, as all other shadows on the Earth happens to have an elongated shape before 9 A.M. in the morning when the sun is quite at a low altitude over the eastern sky. If the shadow would have to run from the north-west comer to the east of India in just about twenty minutes, you can imagine at what fantastic speed the shadow ought to travel while over India, which implies an average speed of about 5000 kilometres per hour. At such a great speed, a mere 100 kilometres length of shadow can stay with a stationery observer for just about a minute. This is what is the maximum duration of this total solar eclipse. In fact, if you are located at the centre of the moon's shadow while it is passing through Rajasthan, the totality will last for only 50 seconds. As the shadow progress eastward, the sun's altitude in the sky will naturally keep on increasing, the shape will also keep on decreasing, much like the length of the shadow of any tree or a tall building decreases with the increasing height of the sun. Near Diamond Harbour (about 50 kilometres south of Calcutta), the sun will stand so high that the maximum duration of the totality will rise to about one minute and twenty seconds. However, the shadow will quickly pass through Burma, Thailand and can reach region of the local mid-noon right into the Bay of South China in the Pacific ocean, where the maximum duration of totality will rise to its maximum of about two minutes and nine seconds. Thereafter, the shadow will keep on moving further eastward for about another hour and a half, by which time the eclipse-making shadow of the Moon will depart from the surface of the earth into the space exactly with the concurrent local sunset at the point of its final exit. By that time your wrist watch will show 42 minutes past 11 o'clock. Thereafter, even though the total solar eclipse would last for about 3 hours and 20 minutes, your chance of viewing it from any appropriate site in India could not have been longer than about a minute or so.

Now, why are we spending so many columns to be featured in our calender for an event which ought to last for hardly one minute, and that too, we are trying to encourage you to utilise your most valuable period of Diwali vacation to plan for a trip to a desert-like place such as Ratangarh or Fatehpur or Alwar in Rajasthan, the Triveni Sangam near Allahabad, a hill resort at Daltongunj or Ramgarh in Bihar, and the Sagar-Sangam in the Deltas of the holy river, the Gangas ? There are a large number of eclipse chaser scientists as well as amateurs, who traveled all the way to the most distant parts of the world in order to be present at the predicted auspicious moments of the totality, yet failed to witness it for as many times as seven or eight, due to a small piece of cloud hiding the sun just at the right time, despite the reputation of their weather conditions that those sites had been credited to in the past. On the other hand, there are a number of lucky eclipse chasers, who did not miss even for once in the consecutive seven eclipse expedition, despite the expected bad condition of the weather at the site of the camp. Would you believe that some reputed travel agents in the USA, Canada, and Europe have already started booking the flights for the forthcoming eclipse trip to India as early as May,1994 ? You have to plan for it from right now.

If you want to draw a chart for the central path of the totality over India, pick up an atlas of India, join a straight line between Fatehpur in Rajhasthan to Tamluk in the District of Medinipur in West Bengal. The southern and the northern limits of the belt of totality can be drawn very easily by taking plus and minus 20 kilometres on either side at Fatehpur, and plus and minus 28 kilometres from Tamluk, and join these northern and southern bounds of the Zone of totality exclusively prepared by yourself. And then you select the place of your choice. Make sure that you get drinking water in the locality, and a suitable place, on rent or otherwise, for camping, because 8.30 A.M. will be too early in the morning to make a trip from a nearby town or village. Try to go as a part of a team. For a layperson, it will be advisable not to carry out any experiments, but simply watch the phenomenon, because there can be no comparision between a partial solar eclipse of even 99 percent coverage of the sun, and the one causing a 100 percent coverage of the sun, the later being known as a total solar eclipse. On an average, it takes about 360 years to have the privilege of witnessing a total solar eclipse from any given place on the earth.

Now, why is it that the phenomenon of a total solar eclipse is exclusively classified as one of the most beautiful celestial events that a human can simply enjoy merely by watching it without requiring any sophisticated gadget ? Just about a minute before the totality, the sky becomes almost totally dark and a thin crescent of the sun remains to be eaten up by the progressing Moon. Up to this time you should use a proper sun glass-filter especially designed for viewing the solar eclipse. Direct looking at the sun is extremely dangerous for the eye. You may collect one or two sheets of mylar, or two layers of fully exposed black and white films used for your camera, or a well-exposed sheet of X-ray films thrown away by any hospital or clinic, and stick in front of your sun glass. Even better would be the welder's glass. But during the totality, you don't require any such filters. The same is true if you are taking some shots in your camera. A proper filter should be used up to one minute before the totality and remove the filter during the eclipse and even for one more minute after the totality is over. The following are the expected sequence of events during the totality.

(a) During the last one minute before the totality, birds and animals will be thoroughly confused at the signal of the unwarranted appearance of the evening dusk. If you are lucky enough (that is, if atmosphere is turbulent enough), you will witness a fast moving wavy patterns of light and dark fringes around, somewhat appearing like innumerable number of snakes crawling around you. Even noted astronomers such as the Late Dr.M.K.Vainu Bappu felt extremely uncomfortable while witnessing such a state of affairs all around himself during

the total solar eclipse of 1970 that he was observing from Mexico. It took him quite a while to realise that what he was witnessing was nothing but the " Shadow Bands ". You can imagine, if a first rank astronomer can be so bewildered at the mere instance of the shadow, you can find an explanation for our age-old tradition of not coming out of the home during an eclipse, lest these crawling snake-like reptiles due to optical illusion created by the instance of shadow bands can poison the whole air and atmosphere. So you are not supposed to eat, close all the doors and windows, and take a thorough bath after the eclipse is over. It is quite natural that some holy wanderers (sadhu or Vairagi's) in the country would witness such an event somewhere or the other part of the country during their life-time to give the testimony of such happening during a total solar eclipse. Since it was not always clear which eclipse would be total one, the people were advised not to take a chance. To-day we know for certain that these are the illusory aspects of the shadow bands, and the age-old fear of seeing a shadow band would cause no physical harm to any body.

(b)Then you would see the shadow of the moon approaching towards you with a fantastic speed, and because of uneven surface profile of the moon will allow the last glowing rays of the sun to reach the observer at the locations on the dips of the Moon's profile, and one would witness one or more flashing beams of the remnant disc of the sun. If you see one such bright flashing point on the rim of moon, it would appear as a celestial ring is hanging in the sky in place of the Sun. Scientists refer this phenomenon as the "Diamond Ring". However, if there are several valleys on the lunar profile allowing a number of such bright spots like the beads of a neck-lace, the phenomenon is aptly christened as "Bailey's Beads", after the name of the scientist who authenticated it for the first time in 1836 A.D.

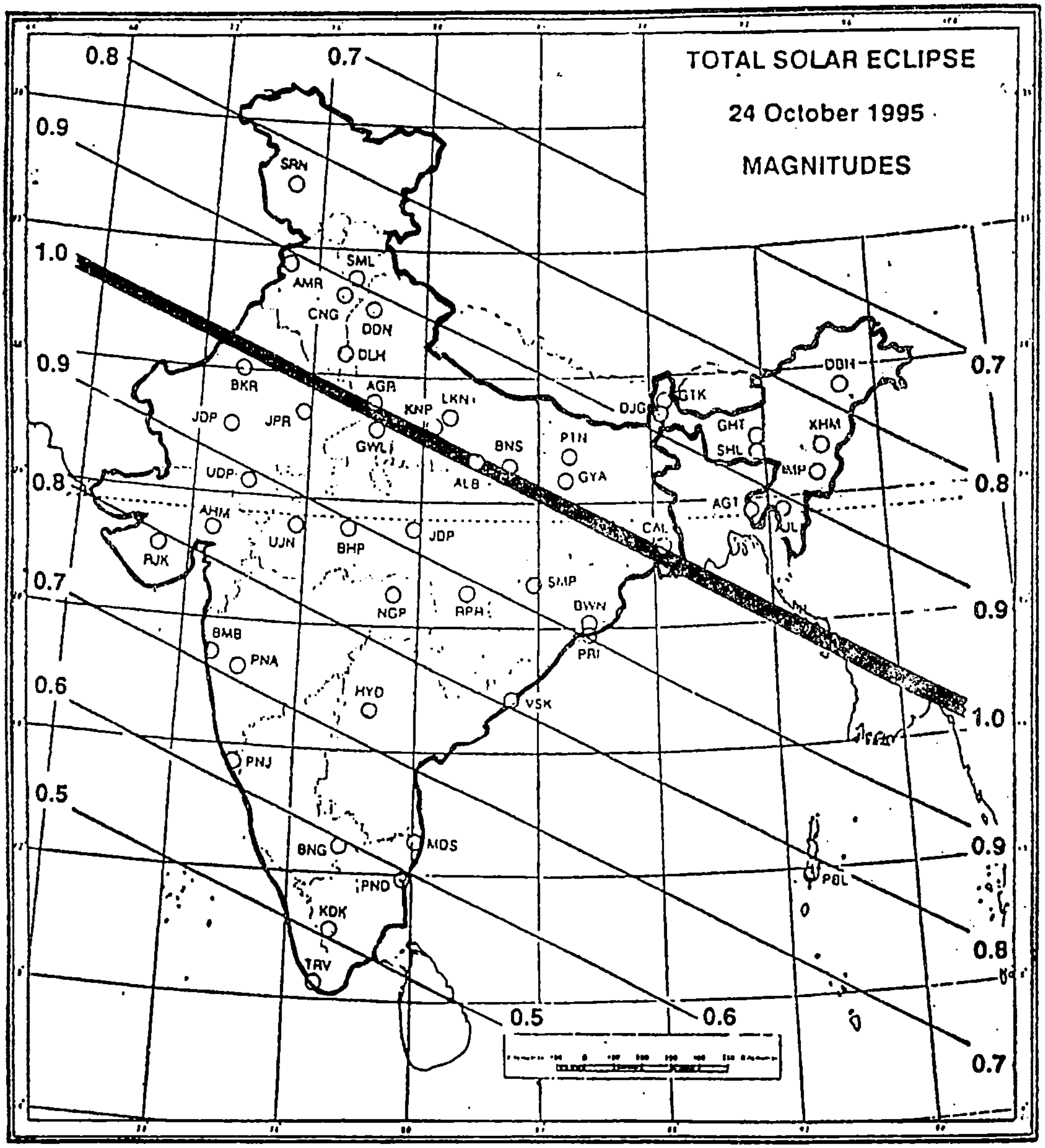
(c) After these phenomenon are over, one can seen a bright rim of the sun. Because of colourful display, this part of the Sun's atmosphere is known as Chromosphere, whereas the brighter disk of the Sun which is already hidden under the dark face of the Moon is aptly known as "Photosphere" of the Sun (Photo means light, 'chromo' means colour). Moon takes about 5 seconds to eclipse the chromosphere, which surrounds the photosphere.

(d) The time ripens for viewing any filamentary structure, if any such being present at that moment, which normally are seen to rise beyond the chromospheric layer of the Sun. These are basically the hot plumes of hot solar material rushing out at a speed of about one or two lakh kilometres per hour. It really gives one the impression that our Sun is not all that quiet, as it appears during the usual sunrise or a sunset (when one even dare to look at the bare Sun. Such filamentary ejections are called, as "Flares" (for the smaller ones) and " Prominences " (for the bigger ones).

(e) When both the photosphere and the chromosphere of the Sun are already eclipsed by the Moon, one visualises a dark disc hanging in place of the sun, and the Sun's atmosphere becomes visible with its full glory. Unlike the Earth's atmosphere whose thickness is not even ten percent of its own radius, the Sun's atmosphere, visible during these few fleeting seconds seems to extend one to three times the normal photospheric radius of the Sun. This extended atmosphere, exclusively visible during the total solar eclipse with the bare eyes, is known as the "Corona" of the Sun. If noted carefully, you would see that the corona is composed of hot streams of gas, and its structural pattern will remind you of the pattern of the iron-fillings that you saw in one of your seventh standard high school experiments in science. Indeed, the Sun is a huge Bar Magnet, sending out hot streams of gas to its surrounding along the lines of force of its magnetic field.

Wish you the best luck for witnessing the exclusively extraordinary event that is going to be visible within at the most a thousand kilometres from your home anywhere in India.

IUCAA, Pune


TOTAL SOLAR ECLIPSE
24 October 1995
MAGNITUDES
0.8
0.7
0.9
1.0
0.9
0.8
0.7
0.6
0.5
0.7
0.8
0.9
1.0
0.9
0.8
0.7
0.5
0.6
SRN
SML
AMR
CNG
DDN
DLH
BKR
AGR
JDP
JPR
KNP
LKN
GWL
BNS
PTN
GYA
ALB
UDP
AHM
UJN
BHP
JDP
RJK
NGP
RPH
SMP
BWN
PRI
BMB
PNA
HYD
VSK
PNJ
BNG
MDS
PND
KDK
TRV
DJG
GTK
GHT
SHL
DBH
XHM
IMP
AGT
CAL
PBL

AMATEUR OBSERVATIONS OF THE SUN

Sanjay R. Kharche

An observation effort helps as a popularity stint, and encourages love for Science in the public in general and young inquisitive minds in particular.

OUTLOOK

i) It is better to practise than just talk and read about amateur astronomer. ii) These are important observations and do not require skill or time. It is good for beginners for groups or for individuals. iii) The data observed reinforces the zurich value. Thus these data have scientific value.

THERE IS POSSIBLE DANGER OF PERMANENT DAMAGE TO EYESIGHT. NO DIRECT VIEWING THROUGH AN INSTRUMENT BE ALLOWED, UNLESS SPECIAL EQUIPMENT IS USED.

We can observe for the Sun, the following i) Faculae and light bridges. ii) Sun spots. iii) Solar Eclipse.

FACULAE

Faculae are bright spots. They appear bright because they are high up in the atmosphere. Apart from polar faculae, these are faculae associated with sunspots. Light bridge is another common bright appearing spot structure. They are seen as luminous, elongated features which extend into large Sunspot complexes. When observed near limb they appear near sunspots, brighter than the faculae.

OBSERVATION METHOD

A very convenient way to look at Sunspots is by the projection method. Sun spot appear if smooth white paper is held at a distance behind the eyepiece of a telescope directed to the sun. This way of viewing can be done in groups also.

The best eyepiece is that of low power, like huygen's type in which the component lenses are not connected together. (Connected lenses are prone to damage by heat.)

By making a frame which can be attached to the telescope we can draw the projection on the screen attached to it.

If we are making daily observations, we must make sure that alignment of the Sun's disc is the same at all times i.e. North-South, East-West can be marked on the screen itself and the sun's image is between the boundaries at all the times.

While observing transit of Mercury, the JVP developed a screen that can be placed and fixed on a CSIO telescope.

We can make daily sunspot observations by getting image of sun by the methods described earlier. We must make observations of

I) NUMBER OF SUNSPOTS
II) SUNSPOT RELATIVE SIZE
III) UNI OR BIPOLARITY
IV) MOVEMENT
V) ACCOMPANYING FEATURES LIKE GRANULES, FACULAE etc.
VI) IF GROUPED
VII) SUNSPOT LONGITUDE

The longitude record can be kept by making daily drawings of the projection image obtained.

By observing change in position of sunspots, we can determine the average period of rotation of the sun. If we can note the latitude of a given sunspot we can observe the differential rotation of sun. It should be kept in mind that the sun's axis of rotation is inclined to that of the ecliptic by about 7 degree 25 minutes. Thus sunspots will generally seem to move about an elliptical path though they maintain their latitude on the sun's surface.

The next total solar eclipse will occur on 24th October, 1995 and will be seen from about 25 Km. off AGRA.

During such an eclipse,

1. Groups could just go and see the eclipse. It's an experience in itself.
2. Bailey's Beads : Inside the path, they will be seen only during totality but along edges, they prevail for longer periods. This phenomenon must not miss the expert photographer's eye.
3. One could just as well take a series of photographs of a given landscape during the eclipse. This will give a dramatic sequence of pictures to demonstrate.
4. Shadow bands : Just before, or just after totality we may observe shadow bands., They may be photographed or recorded on film by a motion picture camera. Careful planning of this activity is required.
5. Biological observations, such as behaviour of humans, dogs, cats etc. can also be interestingly noted.

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A PROPOSAL TO STUDY THE CORONAL STRUCTURES DURING THE TOTAL SOLAR ECLIPSE OF OCTOBER 24, 1995

Jagdev Singh

Abstract : We suggest coordinated photography of the 1995 solar eclipse by amateur astronomers using standardized technique. The amateur astronomers are invited to join this campaign and identify the working groups to be stationed at 30 places stretched along the path of totality in India during the total solar eclipse of October 24, 1995. At each station observers will take pictures of solar corona using a telescope or telephoto lens of about 600 + 200 mm focal length and 35 mm Kodak 2415 film to be supplied centrally. To obtain uniformity in data, films are planned to be developed at Indian Institute of Astrophysics, Bangalore under identical developing conditions. This time sequence of + coronal pictures of about 20 minutes will be useful to study the intensity variations and dynamics of coronal structures.

Introduction : The invention of the solar coronagraph by Bernard Lyot in 1930 notwithstanding a total solar eclipse remains the best means of studying solar corona. The advantage of total eclipse lies in providing a minimum of scattered light background and Fraunhoferline contamination, factors that normally restrict the coronagraph in providing information about coronal structures close to the solar limb and in outer corona. Even a coronagraph in space has the limitation for providing data close to the solar limb. But most of the time a large portion of totality path crosses either over sea or inaccessible regions or both. Moreover, short duration of the total phase of an eclipse makes it difficult to study the temporal variations and dynamics of the solar corona. Fortunately, the tract of total solar eclipse of October 24, 1995 will pass over a large portion of easily accessible regions in India. The total phase of the eclipse will be first seen at Anandgarh in Rajsthan at about 8.30 IST. The track of totality will pass through Uttar Pradesh, Bihar and West Bengal. The total solar eclipse will be visible from Diamond Harbour near Calcutta at about 8.50 IST for 76 seconds or so. The duration of totality in India will vary from 45 seconds in Rajasthan to 76 seconds in West Bengal. Hence, one can observe the solar corona from a place near the central line of totality path only for a minute or so. The data obtained there will not be enough to study the intensity variations and dynamics of coronal structures. One can overcome this difficulty by making observations from a number of places near the central line along the length of totality path in India. Keeping in view the length of track and duration of totality, it is suggested that about 30 observing teams, each consisting of 2-3 persons and 50-60 kms apart may be organised to take the coronal pictures in white light. Table 1 lists the places, chosen because of available easy approach facility, from where this experiment can be conducted.

Observations : The observers need to consider the following to make this campaign a success.

(a) **Telescope :** It is an ideal prerequisite to photograph the coronal structures upto 4-5 solar radii. A telescope or a telephoto lens with an effective focal length of 600 mm yields a 5.5 mm size image. Thus, this telescope equipped with 35 mm film magazines will give us the data upto 4 solar radii in one direction and 6 solar radii in the perpendicular direction. Therefore, it is suggested that one may use a telescope or telephotolens with

a focal length of about 600 + 200 mm. If possible, one may try to fix the 35 mm camera in such a manner that the length of the film lies in the E-W direction because most of the coronal streamers will be in E-W direction due to minimum phase of the solar cycle. The aparture of the telescope or telephoto lens should be adjusted to make the value of f-ratio as 11.

(b) Focusing of the telescope : One should never try to look directly at the image. Intense light from the solar image can cause permanent damage to the eye. To focus the telescope, one can use a diaphragm which may be made of card-board or a thin metal sheet of the size of objective with one hole of 2 mm diameter at the centre and four holes each of about 3 mm diameter, separated by about 90 near the periphery. Cover the objective with the diaphargm and tape it to make sure that it does not fall during adjustments. Open the back side of camera body and keep a ground glass plate at the film plane. One may see five images of the sun if too much out of focus or a big blurred image if close to the focus. Adjust the focussing arrangement to see one sharp distinct image of the sun at the ground glass plate.

(c) Calibration : The relative calibration to convert density values of the solar and coronal images into corresponding intensities will be done at Bangalore before developing. To obtain uniformity of the data and absolute values of coronal intensities, the calibration needs to be done in the following manner. After focussing the telescope and one day before the eclipse or the next day, close all the four holes near the periphery of the diaphragm. Take images of the sun with the central hole of 2 mm and exposure time of 1/1000 and 1/500 seconds at about the epoch of total solar eclipse next day. These observations should be repeated on the day of eclipse but half an hour before as well as after the occurance of the total solar eclipse.

(d) Exposure time during the eclipse : Most of the telescopes for this purpose may not have the facility for tracking the solar image. In that case, bring the solar image in the centre of the field of view about 2 minutes before the totality using the diaphragm. Lock the telescope in position and make sure to remove the diaphragm. When the total solar eclipse begins at the location, take pictures of the solar corona with exposure times of 1/30, 1/15, 1/8, 1/4, 1/2 and ı second. Continuous movement of the image will spoil the image quality of the solar corona for exposures more than one second. Observers having telescopes with tracking facility can take pictures with 1 and 2 seconds also.

(e) Epoch of exposure : The information about the accurate time of the picture taken is important in the study of intensity variation and dynamics of coronal structures. Therefore, observers must correct their watches and keep record of the pictures taken before, during and after the eclipse to an accuracy of one second.

(f) Developing : Observers having developing facility can develop trial pictures of the sun obtained during setting the telescope prior to the total solar eclipse. They should send the film and relevant record about exposures to Bangalore for developing so that all the films can be developed under identical conditions to make sure uniformity in the data.

(h) Analysis of the data : All the pictures of the solar corona will be digitised using PKDS machine of Indian Institute of Astrophysics, Bangalore with a spatial resoluting of 50 x 50 microns. Then all the pictures will be magnified to a chosen size with the help of computer programmes. After converting the density values into intensities and normalisation, the

pictures will be aligned using two dimensional corss-correlation technique. Finally, analysis will be done to study the temporal variations and dynamics of coronal structures.

General remarks : Interested observers are invited to come to Bangalore and take part in analysis of the data. Observers can also get a digitised copy of the pictures if they wish to analyse the data using their own facilities. We hope this kind of effort will yield good scientific results.

Table-1: List of places where the observing camp to be set up

Sl.No.	Name	Approximate	Remarks. Longitude in degrees & Min.
1.	Anandgarh	72 50	Near Indo-Pak border.
2.	Chhattaragarh	73 10	On Anupgarh - Bikaner Road
3.	Lunkaransar	73 45	On Suratgarh Bikaner Railline
4.	Bhadasar	74 18	On Sardarshahr Bikaner Road
5.	Maulisar/Ratangarh	74 40	Ratangarh is a good town about 10 km south of central line of totality.
6.	Fatehpur	74 58	On Ratangarh - Sikar Road.
7.	Nawalgarh	75 15	On Jhunjhunun - Sikar Road
8.	Nim Ka Thana	75 50	On Delhi - Ajmer rail line
9.	Pragpura	76 10	90 km from Jaipur on Delhi-Jaipur Road
10.	Akbarpur	76 30	18 km from Alwaar on Alwar-Jaipur Road
11.	Lachhmangarh	76 50	30 km SE of Alwar
12.	Loharu	77 18	20 km from Bharatpur on Bharatpur-Jaipur Road
13.	Khasiragarh	77 50	10 km west of the main Road from Agra to Dhaulpur
14.	Pahari	78 05	25 km NE of Dhaulpur
15.	Bhind	78 50	30 km from Etawah on Etawah-Gwalior Road
16.	Kalpi	79 45	On Kanpur-Jhansi Road and Rail line.
17.	Hamirpur	80 10	60 km from Kanpur
18.	Ghazipur	80 45	20 km south of Fatehpur
19.	Karai	81 25	50 km west of Allahabad
20.	Allahabad	81 50	Short duration of eclipse - 30 secon
21.	Lalganj	82 20	About 25 km from Mirzapur
22.	Robertsganj	83 05	On the rail line from Varanasi to Daltanganj
23.	Muhammadganj	83 50	On the rail line from
24.	Panki	84 25	50 km by road from Daltanganj
25.	Ramgarh	85 30	On the Hazaribag Ranchi Road
26.	Jhalida	85 58	On Dhanbad-Ranchi rail line
27.	Puruliya	86 20	15 km away from central line Duration will be about 35 seconds
28.	Manbazar	86 40	60 kms from Puruliya
29.	Simla pal	87 05	60 km from Bankura by road
30.	KGhatal	87 45	15 km awasy from central line Duration about 40 seconds
31.	Kola	87 50	On Calcutta-Kharagpur Road
32.	Diamond Harbour	88 25	About 50 km from Calcutta.

Indian Institute of Astrophysics Bangalore-560 034

TOTAL ECLIPSE OF THE SUN, OCTOBER 24

LOCAL CIRCUMSTANCES OF THE TOTAL PHASE FOR CERTAIN PLACES IN INDIA

Place	Eclipse Begins (I.S.T.)	P	V	Totality Begins (I.S.T.)	P	V	Greatest Phase (I.S.T.)	Magnitude	Totality Ends (I.S.T.)	P	V	Eclipse Ends (I.S.T.)	P	V	Duration of Total phase
	h m s	°	°	h m s	°	°	h m s		h m s	°	°	h m s	°	°	m s
Ratangarh	7 23 46	293	352	8 31 15	132	185	8 31 39	1.012	8 32 04	276	328	9 48 28	115	156	0 49
Fatehpur (Raj)	7 23 54	293	352	8 31 34	115	168	8 32 00	1.012	8 32 26	293	345	9 49 05	115	156	0 52
Ramgarh (Raj)	7 23 55	293	351	8 31 40	69	121	8 31 59	1.012	8 32 17	339	31	9 49 00	115	156	0 37
Nawalgarh	7 23 58	293	352	8 31 49	129	182	8 32 14	1.012	8 32 40	279	332	9 49 32	115	156	0 51
Alwar	7 24 26	293	352	8 33 03	91	143	8 33 28	1.013	8 33 53	318	10	9 51 43	115	155	0 50
Bharatpur	7 24 48	293	352	8 34 04	67	119	8 34 24	1.013	8 34 43	341	33	9 53 21	116	154	0 39
Fatehpur Sikri	7 24 52	293	352	8 34 09	84	136	8 34 34	1.013	8 34 59	325	16	9 53 40	116	154	0 50
Dhaulpur	7 24 55	294	353	8 34 35	176	228	8 34 49	1.013	8 35 03	233	285	9 54 11	115	154	0 28
Rajakhera	7 25 05	293	352	8 34 44	78	129	8 35 07	1.013	8 35 31	331	23	9 54 38	116	154	0 47
Bhind	7 25 21	293	352	8 35 19	105	157	8 35 48	1.013	8 36 18	304	355	9 55 50	116	153	0 59
Jalaun (Orai)	7 25 38	294	353	8 36 07	156	208	8 36 30	1.014	8 36 53	254	305	9 57 04	115	153	0 46
Kalpi	7 25 49	294	353	8 36 23	121	173	8 36 54	1.014	8 37 24	288	340	9 57 43	116	153	1 01
Hamirpur	7 26 02	294	353	8 36 52	119	171	8 37 24	1.014	8 37 55	290	342	9 58 33	116	152	1 03
Allahabad	7 27 03	294	352	8 39 28	36	86	8 39 35	1.014	8 39 41	14	65	10 02 08	116	151	0 13
Robertsganj	7 27 49	294	353	8 40 39	116	166	8 41 13	1.015	8 41 48	295	345	10 04 52	116	149	1 09
Churk	7 27 50	294	354	8 40 43	127	178	8 41 17	1.015	8 41 51	284	334	10 04 58	116	149	1 08
Garhwa	7 28 24	295	354	8 41 59	156	206	8 42 26	1.015	8 42 53	255	305	10 06 50	116	148	0 54
Daltenganj	7 28 32	295	354	8 42 20	163	214	8 42 44	1.015	8 43 08	248	298	10 07 19	116	148	0 48
Barkakhana	7 29 38	295	354	8 44 15	111	160	8 44 52	1.016	8 45 29	301	350	10 10 38	117	146	1 14
Ramgarh (Bihar)	7 29 42	295	354	8 44 23	99	148	8 44 59	1.016	8 45 35	313	2	10 10 48	117	146	1 12
Ranchi	7 29 34	295	355	8 44 32	182	232	8 44 47	1.016	8 45 03	230	280	10 10 34	116	146	0 31
Puruliya	7 30 25	295	354	8 45 52	75	124	8 46 20	1.016	8 46 49	337	26	10 12 53	117	145	0 57
Chandrakona	7 31 26	295	354	8 47 39	92	140	8 48 15	1.016	8 48 52	320	9	10 15 49	117	143	1 13
Medinipur	7 31 19	296	355	8 47 51	184	233	8 48 05	1.016	8 48 20	228	277	10 15 38	116	143	0 29
Ghatal	7 31 37	295	354	8 48 02	85	133	8 48 36	1.016	8 49 10	327	15	10 16 19	117	143	1 08
Balichak	7 31 31	296	355	8 48 03	168	217	8 48 28	1.016	8 48 52	244	293	10 16 11	116	143	0 49
Panskura	7 31 39	295	355	8 48 03	138	186	8 48 40	1.016	8 49 18	275	323	10 16 29	117	143	1 15
Uluberia	7 31 51	295	354	8 48 24	96	144	8 49 02	1.016	8 49 40	316	4	10 16 59	117	142	1 16
Tamluk	7 31 54	295	355	8 48 31	134	183	8 49 09	1.016	8 49 47	278	326	10 17 12	117	142	1 16
Amta	7 31 54	295	354	8 48 39	69	117	8 49 06	1.016	8 49 34	343	31	10 17 04	117	142	0 55
Falta	7 32 02	295	354	8 48 44	123	171	8 49 24	1.016	8 50 04	290	338	10 17 33	117	142	1 20
Budge Budge	7 32 03	295	354	8 48 50	84	132	8 49 24	1.016	8 49 59	328	16	10 17 32	117	142	1 09
Diamond-Harbour	7 32 08	296	355	8 48 56	135	183	8 49 34	1.017	8 50 13	278	326	10 17 50	117	142	1 17
Kulpi	7 32 12	296	355	8 49 07	147	195	8 49 42	1.017	8 50 17	266	314	10 18 01	117	142	1 10
Haldia	7 32 02	296	355	8 49 10	185	233	8 49 25	1.017	8 49 40	228	276	10 17 37	116	142	0 30
Lakshmikant-pur	7 32 16	296	355	8 49 10	135	183	8 49 49	1.017	8 50 28	278	326	10 18 12	117	141	1 18
Baruipur	7 32 20	295	354	8 49 24	75	122	8 49 54	1.017	8 50 25	338	26	10 18 16	117	141	1 01
Basanti	7 32 35	295	354	8 49 49	81	129	8 50 23	1.017	8 50 56	332	19	10 18 59	117	141	1 07

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PATHANI SAMANTA PLANETARIUM

S. Torasia

Mahamahopadhyaya Samanta Chandra Sekhar happens to be the last link in the long orders of traditional astronomers of this country. It is a matter of pride for the State of Orissa that a Planetarium has been established in the State after his illustrious name.

Establishment of the Planetarium was decided in 1985 and building work was taken up in 1986. The Planetarium staff were appointed in 1988 and the institution was officially inaugurated on 8th January, 1990. The first Programme presented by the Planetarium was 'Joumey to the Planets'.

The Planetarium is ideally situated on a beautiful 4-acre plot on the Acharya Vihar Square by the side of the Nandankanan Road within an Educational Complex. Near by are the Utkal University, Regional College of Education, Regional Science Centre, Regional Research Laboratory and Institute of Physics. The building of Orissa Computer Application Centre, in the adjoining plot is under construction. The Regional Museum of Natural History, the Institute of Life Sciences and Orissa Bigyan Academy have also selected sites on the plots adjoining to the Planetarium.

This universe more, vast than our imaginings and filled with wonders more than we can dream is a heritage for all mankind. Planetarium is a theatre that brings the awe and wonders of the universe to its citizens. It is a theatre that brings to women and men, to parents and children, the marvels of the universe that gave them birth. The vast sky with myriads of stars, planets and the moon is an environmental treasure that can be shared by all people. A planetarium is a theatre that showsl and shares this treasure.

The moral is that a Planetarium is an educational unit that creates awareness of astronomy among the students and the common mass. Pathani Samanta Planetarium has been operating for last five years with the afore-said objectives in view. Besides the first programme already mentioned, the Planetarium has presented eleven more programmes at various times. They are 'The Mysterious Mars', 'The Worlds & Weathers', 'The Visitors from outer Space; "Ananta Akash", "HUBBLE - Report from orbit", "Ama Soura Jagata", "Our Cosmic Heritage", " Solar Family", "Moon - Our Neighbour in Space" etc. All the programmes presented in this Planetarium with varied audio-vidual settings are completely absorbing for people of all ages. In fact, experience of a few minutes inside the planetarium takes the observer away to different worlds and particularly, as we have marked, the thrill of the children is unforgetable. Thousands of visitors every month enjoy this unique opportunity.

The Planetarium conducts Night Sky Watch Programme for three days following the new moon, where important star clusters are identified to the general public as well as students and details of the planets and moon are shown through the telescopes. Some times we have sought the cooperation of Regional Science Centre, Bhubaneswar, Srujanika and such other organisations in this venture.

The Planetarium is bringing out a bi-monthly bulletin in the form of a wall poster titled "Pathani Samants Planetarium Mukhapatra CHHAYAPATHA" in Oriya language. The periodical presents absorbing articles, upto date information, recent discoveries and historical anecdotes in Astronomy and Space Science in lucid form. This publication in the field is unique in the State.

The Planetarium puts constant efforts in educating the people on rare celestial phenomena. The demonstration of the last transit of Mercury on the Sun attracted thousands of excited onlookers to this centre. Members of staff regularly contribute articles on astronomy to newspapers and magazines. They present even radio and television programmes on these theme.

Research is being carried out in the Planetarium, in physics and Astronomy. The contribution of Samanta Chandrasekhar is one of the important research projects presently being pursued.

It is hoped that in near future this institution, unique of its kind in the State, will stand as a very good centre of learning apart from its usual operation through the sky theatre.

Director
Pathani Samanta Planetarium
Bhubaneswar - 751 013

THE INTER-UNIVERSITY CENTRE FOR ASTRONOMY & ASTROPHYSICS

Jayant Narliker

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The birth of the Inter-University Centres

In 1985 the University Grants Commission through an act of Parliament, set up a number of centres designed to act as national coordinating bodies to create centralised facilities, shared by all universities and managed by the autonomous "inter-university centres" (IUC). The first IUC to be established was the Nuclear Science Centre in Delhi. The second, our own, Inter-University Centre for Astronomy and astrophysics (IUCAA).

The IUCAA was set up to ensure that the very real interest in astronomy and astrophysics in India can finally attract the resources required to enable us to pursue research programmes comjparable to those in other countries. In Europe, the United States, Canada, Australia and Japan, astronomical programmes considered highly ambitious a generation ago, are becoming reality thanks to rapid developments in technology. Most facilities in these countries are either national or multinational. Rarely is usage confined to a single institution or university. Even where management is vested in a particular organisation, the "guest observer program" encourages outside observers to participate.

These exciting developments had found echoes (albeit modest ones) in India too. The 2.3 m Vainu Bappu Telescope at Kavalur is one of the largest optical telescopes on Asian soil. The 1m infra-red telescope at Gurushikhar has the benefit of a very good astronomical site. The 10 m dish at Bangalore is equipped for state of the art work in millimetre wave astronomy. And, perhaps the most ambitious project, the Giant Metre-Wave Radio Telescope, an initiative of the National Centre for Radio Astrophysics. However, until the establishment of the IUCAA, these facilities were associated with a university only very tenuously, if at all.

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The future for the IUCAA

To some extent the IUCAA has been patterned on the International Centre for Theoretical Physics at Trieste (ICTP), with a small permanent core faculty and a large number of "visitors". With this model for our institution we have eight major objectives we hope to fulfil. Our first commitment is producing a core group of studennts and lecturers, capable of interacting with their peers in universities and research institutes. Secondly, by communication with other groups we hope to be able to devise and implement lasting programs for the introduction of astrophysics to students at all levels. Even youngsters at elementary levels will not be overlooked. Our third and fourth objective is to train current teachers and lecturers to be even more effective in their teaching of astronomy and astrophysics.

The fifth objective for the IUCAA is the establishment of an Associateship

Programme such as that run by the ICPT. Under this arrangement an associate of IUCAA can visit the centre for long or short poriods to take advantage of its centralised facilities of visiting resource persons. Travel and living expenses for such trips are borne by IUCAA. Directed at university and college teachers, this program is expected to improve mobility amongst the associates, increase contact and promote interactions between scientists who might otherwise feel isolated.

IUCAA's sixth and seventh nobjectives are geared towards promoting the use of major astronomical facilities for research by the staff and students of universities and colleges. One of the facilities which will enable us to deliver practical, observational programmes is the development of an automated photometric telescope and related detectors. A prototype with 14 inch aperture is ready. During the year groups from the universities of Bangalore and Gujarat will assemble similar telescopes in our laboratory for their own use. We already have plans to further upgrade the prototype by adapting it for imaging and photometry with CCDs.

As observational activity picks up, a telescope of around 1m aperture will be developed to cater for the needs of universities over the next few years. Among other instruments under development is a liquid nitrogen cooled CCD camera. Designed as a low noise device, it will be used on existing national telescopes. We will then use the experience gained by building this instrument to provide compact, thermoelectrically cooled CCD cameras for small telescopes sited at various universities. Since the siting of IUCAA in Pune was dictated to a large extent by the location of the GMRT at Narayangaon, IUCAA's sixth objective is specifically to bring the university community into closer interaction with the GMRT as well as encourage guest observer programmes at other major facilities in the country and abroad by the uiniversity community. In many ways, IUCAA will act as a catalyst for potential astronomers in the university sector.

The eighth and final objective strikes at the root of it all : to participate in the popularisation of science through the interaction with amateur astronomers, young students and the general public. At present there is hardly any exposure to astronomy and astrophysics at the school level. To redress this situation we have designed several programmes especially for school children. These include summer projects, monthly lectures and demonstrations for school groups. For the general public we have organised popular lectures and night sky viewing. To further stimulate our active amateur community we now hold workshops on a broad range of topics, from the practical aspects of building your own telescope to introductory astrophysics. We also encourage the creation of planetaria all over the country as a means of bringing the night sky to the poublic, free from the constraints of bad weather. Through these initiatives we hope to feed the sense of wonder people feel, while educating them about science.

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Prof Jayant Narlikar is Director of the IUCAA. His major research areas involve cosmology and he is one of a team working on the quasi-steady state cosmology. Apart from poure research, Professor Narlikar has written many works ,on astrophysics which have been published in Marathi, Hindi as well as English. His scientific research has not prevented his from indulging in a favourite pastime, writing popular works of science fiction.

(Excerpt from an article in the Southern Sky, May-June, 1994)

SAMANTA CHANDRA SEKHAR AMATEUR ASTRONOMERS' ASSOCIATION (SCAAA)

P.C. Naik

An Amateur Astronomers' Association was formed at Bhubaneswar on 17.07.1993 by a resolution adopted in a meeting of a group of zealous members from Institute of Physics, Department of Physics, Utkal University, Vani Vihar and from Pathani Samanta Planetarium. The meeting was held at the Department of Physics, Utkal University. The Association was given the present name in a subseaquent meeting held at Pathani Samanta Planetarium on 28.08.1993. The Association got registered under the Societies Registration Act in June, 1994.

During the brief period after its birth, SCAAA has strived hard to spread the excitements of astronomy in the state. It holds regular monthly meetings on Sunday, following the second Saturday each month, where educative items of astronomy are discussed. The Association has organised two Telescope Making Workshops in Pathani Samanta Planetarium, in which students from various parts of the state have participated.

SCAAA has adopted model talks prepared by individual members to be delivered at various schools. This programme is running satisfactorily. During rare celestial events like the Transit of Mercury and Comet Crash, the members of SCAAA have whole heartedly co-operated with Pathani Samanta Planetarium, in observation, demonstration and dissemination of the information among the public.

Samanta Chandra Sekhar Amateur Astronomers' Association has decided to take up publications in the field of astronomy. The first result of this venture is an astronomical glossary, from English to Oriya, which has been prepared by one of our active member, Sri P. K. Mishra, a retired Defence Scientist. The work awaits publication. SCAAA plans in a big way for utilising the chances of the Total Solar Eclipse - 1995.

The Association aims at reviving the rich astronomical commitment and culture, in Orissa, which Satananda and Samanta Chandra Sekhar created as single man phenomena.

In fact, the V AIAAM is one of the major events in the life of SCAAA. The event has been geared through this Association. The Association whole heartedly involved in its organisation and wishes great success for this Meet.

Secretary, SCAAA

CONFEDERATION OF INDIAN AMATEUR ASTRONOMERS (CIAA)

B. K. Pattanayak

Amateur Astronomy activities in India picked up slowly in early eighties. Attempts were made by the then groups of different states to form a national federation of the amateurs. Meetings were held in Vadodara (Jannuary'84) and in Pune (January'91). The first All India Amateur Astronomers' Meet was organised at Pune (1991). This was followed by the Wardha (1992), Ahmedabad (1993) and Calcutta (1994). The V Meet is being organised in Bhubaneswar (1995). The Confederation of Indian Amateur Astronomers' (CIAA) came into being on 22nd January, 1994 at Calcutta. The main aim of this national body is to coordinate all amateur astronomy activities and to disseminate astronomy among people.

OBJECTIVES :

To inculcate scientific temper in the young and adults through astronomy related programmes.
To involve Amateur Astronomers in more project oriented activities in an organised way for effective data collection that can be of some research value.

To involve more people in professional institutions in the field of astronomy with proper motivation.

To develop Regional Centres, and if possible, one or more observatories for amateurs in different parts of the country.

ACTIVITIES :

Observation : to encourage people to observe the stars, constellations, messier objects, variable stars, comets, meteor shower and occultations etc.

Instrumentation : to help procure the right kind of instruments for obser vation at the lowest possible cost. Telescope makers can concentrate on quality of optics rather on sky observation. The astrophotographers can take photographs during observations.

Popularisation : introducing school level projects, conducting certificate courses, generation of centralised resource materials for exhinbition, conducting seminars, debates and essay contests, astrocartoons, bring ing out slides and audio and video cassettes etc. There can be lectures with audio-visual supplements.

The CIAA brought out its first Newsletter in october'94. The second issue is being released during this Meet.

REGIONAL SCIENCE CENTRE

J. Sthanapati

The Science museum has been accepted throughout the world as one of the best media for creating science consciousness among the masses. Its role in developing countries has been not only to disseminate science education to the students and to the laymen, but also to portray the application of science and technology for economic growth and improvement in the standard of living, environment and social welfare. Unlike western countries, the development of science museums has been rather slow in the developing countries. India has been a pioneer amongst developing countries and paved the way by establishing the Birla Industrial and Technological Museum in Calcutta in 1959.

Regional Science Centre, the first science museum in Orissa, was created at Bhubaneswar with Regional College of Education, Regional Research Laboratory, Pathani Samanta Planetarium and Utkal University as its learned neighbours. With part financial help from the Department of Science and Technology, Government of Orissa, the centre was developed by National Council of Science Museums, an autonomous organisation under the Ministry of Human Resource Development, Government of India, in order to provide activity-based learning process to students, inculcate the spirit of enquiry, foster creative talent and motivate people to develop into the mysteries of science. The project work started in early 1986 and the centre saw the light of the dawn with its formal inauguration on 18th September, 1989.

The heart of the centre is a magnificent building of artistic excellence that stands elegantly amidst a flora of lush green grass commensurating with the scenic beauty of the temple city. The building houses three permanent galleries which contain a series of fascinating exhibits on topics such as 'The Sun', 'The Sun sustains life on the earth' and 'Fun Science'. Here, a visitor can explore, experience and discover the science in action and the embodiment of theories into perceptions as he makes a journey into the realm of mystery by going through these exhibits. A large Science Park, sprawling over 5 acres of lush green landscape, provides the visitors with an opportunity to relax in the colourful surroundings away from din and bustle of the city life and allow the children to dissipate their extra energy with an array of outdoor exhibits on physical science and life and tender animals.

Supplement to these permanent facilities, the Centre frequently organises a multitude of educational programmes. It runs Mobile Science Exhibition vans that carry message of science to the doorstep of the common people. Presently, the centre is having two such mobile units i.e. on "Light & Sight" and "Our Universe", and so far, the units have covered all the districts of Orissa enlightening as many as 9,79,300 odd visitors in total.

The other regular activities conducted by the centre include science demonstration lecture, public demonstration lecture, anti-superstition demonstration, creative ability programme, teachers training programme, computer awareness programme, pet club, popular science lecture, and of course, science film shows.

Activities on astronomy in the centre receive the highest priority as symbolised by the exhibits of the main gallery which were devoted to the "SUN". Regular sky observatiuons are made with telescope interspersed with programmes on such special celestial occasions as "the nearest approach of planet Mars to Earth", " transit of Mercury on Sun " etc. Frequent telescope making programmes are taken up among students to encourage amateur astronomical activities in the state. Added to these, what really a boon for the visitors, is an inflatable dome planetarium called Taramandal. The wonderful and awe-inspiring night sky comes alive with all its stars and constellations into the domain of this dome which provides an excellent platform for strong interaction on the part of the visitors and a planetarium-oriented classroom at work for students. The Centre paid its tribute to Pathani Samanta, a local astronomer not only known in the state but in the world at large as an innovative instrument-maker and for his practical observations of the instruments used by the great man for his astronomical investigations.

Over the last two years, the Centre has been instrumental in developing a magnificent Science Centre at Dhenkanal and a Science Park at Kapilas which are already opened to public. These Centres, which use the latest trend and outcome of museum research and technology, are most versatile, complete and will go a long way in propagating the process of non-formal science education in the districts.

Among the future plans, the Centre looks forward to set up two more ambitious district level Science Centres in the state at Jeypore and Sambalpur with the usual support of DST, Govt. of Orissa. Also, project work has started for the expansion of the existing Science Park to include ecological corners, biological and botanical specimens etc.

Last but not the least, the Centre is proud to have a well developed infrastructure, like workshop facilities, electronics and art sections etc. and of course a battery of highly expert professionals, to carry out fabrication of exhibits and render uninterrupted support to educational activities for any length of time.

Regional Science Centre,
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SRUJANIKA

A Society for Research & Innovation on Science, Education and Development

N. M. Pattnaik

Srujanika, a group concerned about science, education and development in a socially relevant context, has been in operation since the early eighties. After the conceptualisation and initiation phase it was registered as a society in 1987. Since 1990 it is operating from its present spacious campus in Jagamara.

Objectives : The main objectives of Srujanika are :

1. To foster creativity, especially in the young mind, by encouraging a child's natural curiousity and innovativeness.

2. To create among the adults a deeper understanding and appreciation for science - its roots, method and application towards a wholesome development.

Approach : Our work approach in these areas has been firstly

1. to generate, collect and adapt for local use, ideas, methodology, written & activity materials and

2. to disseminate these through interested individuals, groups and other existing institutions. We function more as a resource centre keen on interacting with and extending support to workers at various levels.

Specific Activities :

1. *Interaction Programmes* : Since teachers/ adult guides are central to Srujanika's approach to spreading its ideas, orientation workshops for them are a regular activity. These help us in sharing experiences, developing new programmes and involving new associates.

Camps for children, besides being an exciting event for the participants, act as a model for our associates to follow at their places. The workshops and camps usually have a general theme which run for a whole year.

Some of the past themes have been : Fun with Science (1988-89). Nature, Science and Society (1988-90). The Sky (1992-94).

2. *Publication* : Both reading material and activity books are produced to serve as continuous input for all associates and others. These are generally in form of low cost booklets with lots of illustrations.

Srujanika's major publication has been the monthly Bigyan Tarang, now in its sixth year. It plays a link role for our ideas and acvitities. It tries to convey the spirit, rather than the mere facts, of science and that too in a thought provoking and explorative manner touching upon its history, development and future implications.

3. *Science Toys, kits and other softwares* : Toys and other hands on materials play a major role in making the learning process enjoyable. These take away the fear of machines and abstract ideas and encourage the translation of mental pictures into concrete hand made models. Srujanika tries to make available, at reasonable cost, such materials and components. These vary in range from magnets, lenses, motors, packets of bulbs and wire etc., to assembled models of telescope, microscope etc., all of which make science an exciting activity to take part in.

To reach out to larger groups Srujanika has developed/ adapted a number of audio-vidual (posters, slides etc.) materials. Distribution of books, mostly not available through commercial channels, of relevance to Srujanika's objectives is another activity which reaches out to more serious adults.

4. *Srujanika and the sky* : For us science and learning begin with things around us. The objects in the sky, although distant physically, are very close to every child's mind - be it the Sun, Moon or the Stars. Thus, the sky in general, and the star-studded night sky in particular, provides us with a valuable setting to excite the curiosity and a sense of woner in every human mind.

With this view in mind Srujanika has just completed a projec - " The Sky Festival" - spanning over the past three years. In course of this we have developed specific reading and activity materials relating to the celestial objects and the universe. We have also prepared sky charts and sky calenders for Orissa area and compiled star names in Oriya for general use. A book on star watching, a set of posters and a guide book on "The Universe ", slide shows, educational T.V. programmes, newspaper articles etc. are some other activities we have undertaken for this.

In addition, our range of science toys has expanded to include telescope models and kits, star dials etc. to help the sky lovers. We have also conducted workshops/ lecture programmes on sky related subjects in collaboration with Pathani Samanta Planetarium, SCAAA and other interested groups to widen public interest in sky watching.

Through the foregoing approach and activities Srujanika tries to sensitise diverse individuals and groups who can initiate appropriate changes around them. A large number of such decentralised and small but committed steps, we believe, will eventually bring about much larger and deep-rooted changes in the future.

Srujanika, Jagamara,
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